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An investigation on Vernacular Architecture of Marpha, Mustang, Nepal and understanding the influences and changes in architecture and its sustainability

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An investigation on Vernacular Architecture of Marpha, Mustang, Nepal and understanding the influences and changes in architecture and its sustainability

by

Asmita Dahal

Thesis

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Dedication

I would like to dedicate this to the high mountains, tilted trees and scary roads of Mustang, Nepal where the beautiful and kind soul lives in simplicity and ground to earth. And of course, to my parents, my brothers and my friends who made it easy when the times were hard.

Acknowledgment

I would like to thank, my supervisor Juliana Felkner and Michael Garrison who supported me for this research and helped me in all possible ways. They guided me to give proper shape to my thesis and I am grateful towards them.

I am grateful to my family. Despite being born as a girl in an underdeveloped country, they gave me courage and blessing to travel 8000 miles away from home alone to make my dream a reality.

I am thankful towards all those kind and helpful souls, who came as a friend in my life to handle my panics and drama. I am especially thankful to my friend who came at 1:00 am to my home, cooked food for me, took care of me when I was sick and in bed away from home and loved one.

Without them, I won't be this person who I am today.

Abstract

An investigation on Vernacular Architecture of Marpha, Mustang, Nepal and understanding the influences and changes in architecture and its sustainability

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The University of Texas at Austin, 2019

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Nepal, known as the country of Mountains, Gurkhas, and Lord Buddha is also a country rich in Art and Architecture. With the highest point 8848m (Mt. Everest) in the north to the lowest point 70m from sea level, Nepal has diverse climatic zones resulting in the opportunity for the different diversities of architecture throughout the country. In this thesis, the vernacular architecture and settlement pattern of Mustang district particularly Marpha and Jomsom are studied to understand its environmental adaptivity and sustainability from three different overlapping perspectives: Environment, Culture, and Modernism.

The changes in architecture, culture, and settlement are an important part of any development. Being the intellectually aware and technologically forward generation of the 21st century, now we should be able to develop or change in the more sustainable way. This research tries to connect the gap between the vernacular architecture and settlement that had respect towards climate and culture to the contemporary development where that respect and awareness cannot be seen.

Vernacular architecture is the result of hundreds of years of optimization to provide a comfortable shelter in a local climate using available materials and known construction

technologies.[1] In developing or least developed countries like Nepal, we can see how traditional buildings are being replaced by contemporary architecture. Due to the advancement of the technologies, the use of passive solar measures to achieve thermal comfort conditions can be seen disappearing in contemporary constructions.

The purpose of this research is to understand the design strategies applied in vernacular architecture, changes that we can see in architecture and settlement now, analyze these studies and propose the set of design strategies that are best in today's society with changing the culture, climate, and modernism.

Keywords: Vernacular Architecture; Mustang, Contemporary Architecture; Mustang; Change in Settlement Pattern; Mountain Architecture; Climate responsive architecture; Solar analysis; Energy Simulation; Recommended design strategies

[1] *Susanne, B., J., H. and Werner, L. (2016) 'Climate responsive building design of Vernacular Architecture in Nepal', Energy and Buildings 81 (2014) 227–242.*

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Chapter 1: Introduction

Each country has its own unique identity, own unique culture, and own unique architecture. From developed countries to least developed countries around the world we can see that uniqueness in the vernacular architecture in old settlements. These traditional buildings are more connected and respectful to that place, environment, culture, and people. The vernacular and traditional buildings in every area are a product of the accumulated experience and practice of many centuries and can constitute a continuous source of knowledge.[2]

However, with the development of technologies, we can see the replacement of these vernacular architectures with contemporary concert architecture all around the world. In most of the developing countries, it can be observed that with the modernization of the building sector this traditional knowledge of smart and climate responsive design is being lost.[3] It is a sad fact that how the architecture around the world is changing in such a way that it has no uniqueness left. The building in India with such a diverse culture has started to look the same as the building in the USA or in London.

One of the main reasons for building to change in such a pattern is the innovation of the air conditioner. Since people were able to create desire microclimate inside a building with the use of AC, the respect and concern towards the immediate surrounding were neglected. Now, we know that this innovation, that changed the era of architecture, is also responsible for climate change.

Buildings consume some 40 percent of the energy in the U.S. annually, and they emit nearly half of the carbon dioxide (CO2), through greenfield development, cement production, and the burning of fossil fuels such as oil, gas, and coal. Because CO2 traps solar energy in the atmosphere, thereby heating the planet, it is the chief agent of climate

[2] *A., O. and F., B. (2010) 'Architectural structure and environmental performance of the traditional buildings in Florina, NW Greece', Building and Environment 46 (2011) 669-689.*

[3] *Susanne, B., J., H. and Werner, L. (2016) 'Climate responsive building design of Vernacular Architecture in Nepal', Energy and Buildings 81 (2014) 227–242.*

change.[4] The way we design, construct, demolish and reconstruct is increasing global warming and making the planet hotter and harder to live in.

In this research, the idea of finding a middle ground between the vernacular architecture and the modern contemporary architecture in a developing or least developed country where the change in architecture style from the traditional way to contemporary one is happening was explored. The culture, technology, climate, and people are changing. So must the architecture. But there should be a better and more sustainable way of changing so that we can be more respectful towards the climate and environment. The buildings should be a shelter, a place for protection, not the reason behind making our home (Earth) unlivable.

For this experiment/research, the Mustang district of Nepal was taken as the case study. The villages Marpha and Jomsom of Mustang district were taken where most of the buildings are vernacular with unique architectural style. On a high-lying plateau on the Nepalese Territory near the Tibetan/Chinese border and hemmed in by a chain of mountains, some 6000m tall, lies the former small kingdom of Mustang.[5] Mustang was 'Forbidden Kingdom' until 1992 which makes the vernacular architecture more preserved and less influenced from modernism. After 1992, tourism was introduced along with modernism, and now this is one of the developing villages of Nepal. We can clearly see the transformation from vernacular architecture to the contemporary one along with the change in settlement pattern which makes this place a perfect place for this case study.

The goal of this research is to understand the important design strategies from vernacular architecture, understand different aspects for the change in architecture, analyze both architectural style and settlement patterns (old and new) and propose a new set of design strategies that will be climate-responsive, culture responsive and towards development.

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[4] Ned, C. (2017) 'The Climate Is Changing, So Must Architecture.', THE JOURNAL OF THE AMERICAN INSTITUTE OF ARCHITECTS, 4 October.

[5] Susanne von der, H. (2000) 'Changes and Developments in Upper Mustang, Nepal: Decision making at the Local Level', Library of Tibetan Works and Archives, Vol. 25.

RESEARCH QUESTIONS

What can we learn from vernacular architecture? Are all the design strategies from vernacular architecture climate-responsive and sustainable?

What could be the smart and sustainable way of changing architecture along with the change in culture, climate, and development?

What are the factors influencing the change in architecture and settlement pattern? Are those changes respecting the culture, climate, and environment? If not, then what could be the proper strategies for that change?

For the purpose of this thesis, this research is divided into three parts: I) Study of Vernacular Architecture and settlement patterns, II) Study of contemporary Architecture and settlement patterns, and III) Analysis and Recommendation. Chapter 2 of this report consists of a) the brief literature about the vernacular architecture and how these architectures are changing and impacting the environment, b) the introduction of the research area and c) the brief description about the research methodology. Chapter 3 includes the data and analysis of the settlement. Chapter 4 and Chapter 5 include the research and the analysis of the vernacular architecture, contemporary architecture and the influences that caused the changes are explained. In Chapter 6 the recommended set of design strategies is explored.

Research Design

This research is divided into two parts. The first part of the research was done in 2015 with six group members in which we went to Mustang, conducted the field survey and collected the data about household and buildings. The second part of the research is done from 2018 onward. In the second part, the analysis of the conducted data is done to understand the difference in the architecture on the Mustang and how it is changing in term of sustainability. With the collected data and analysis, the set of design guidelines is proposed.

METHODOLOGY

First phase:

Before commencing the data collection process, we (a group of six) thoroughly conducted a literature review and studied the secondary data. It helped us gain an idea of what the place is like and what kind of information we are going to get. It helped us prepare questionnaire and criteria upon which our research would be based on.

Data collection and sampling was a major part of our report. We surveyed in each household to discover findings that somehow matched with literature review. On the course, we also experienced new discoveries regarding population distribution and building types, ages, etc. With this, we collected much more and fresh information of Marpha. Besides, we also got further information through interaction with local villagers, social workers, and leaders of the village. Regardless of this many new information was also collected based on observation for the further futuristic projects for the development of the village.

Second Phase:

The data about the buildings collected from the first phase is analyzed in detail. The vernacular architecture and the contemporary architecture of Marpha and Jomsom are studied in term of sustainability. One typical vernacular architecture of Marpha is studied in detail and then the same building is changed into contemporary architecture to see the

changes and the understand the impact of those changes on the climate and the culture. Trying to understand the sustainability principles that have been adapted since hundreds of years is one of the main purposes of this research whereas, along with that the sustainability principles that can be seen in the developed countries is studied and compared with the principals that we saw in the vernacular architecture and settlement. The main focus of the study is to figure out the path of development in developing countries like Nepal is either or not in the right one taking the reference of LEED as the sustainability principles.

Since this is the case study research and the case study are taken in the underdeveloped country Nepal, collecting data regarding temperature and climate has been the real challenge. Since there is no concrete data regarding the climate, the data collected by the Nepal Government, the software Meteonorm and the data found on the website: https://www.worldweatheronline.com/mustang-weather-averages/np.aspx were collected, compared and analyzed. With data collected from different sources, the .epw file was created with the help of software name Elements. .epw file is the format with the climatic information about the temperature, humidity, solar radiation and wind speed that can be used for the energy analysis in different softwares like open studio, energy plus, climate consultant etc. The program Climate Consultant is then used to analyze the collected climatic data. The SketchUp with the plugin DeLuminae was used for the daylight autonomy study. The online sun calculator was used for the study of the sun position and the shadow mask for both vernacular and the contemporary architecture of Marpha.

After the study and the analysis, the Mahoney table, psychrometric chart, and the biometric chart are used to the generalize the recommendation for the design guideline for Marpha, Mustang.

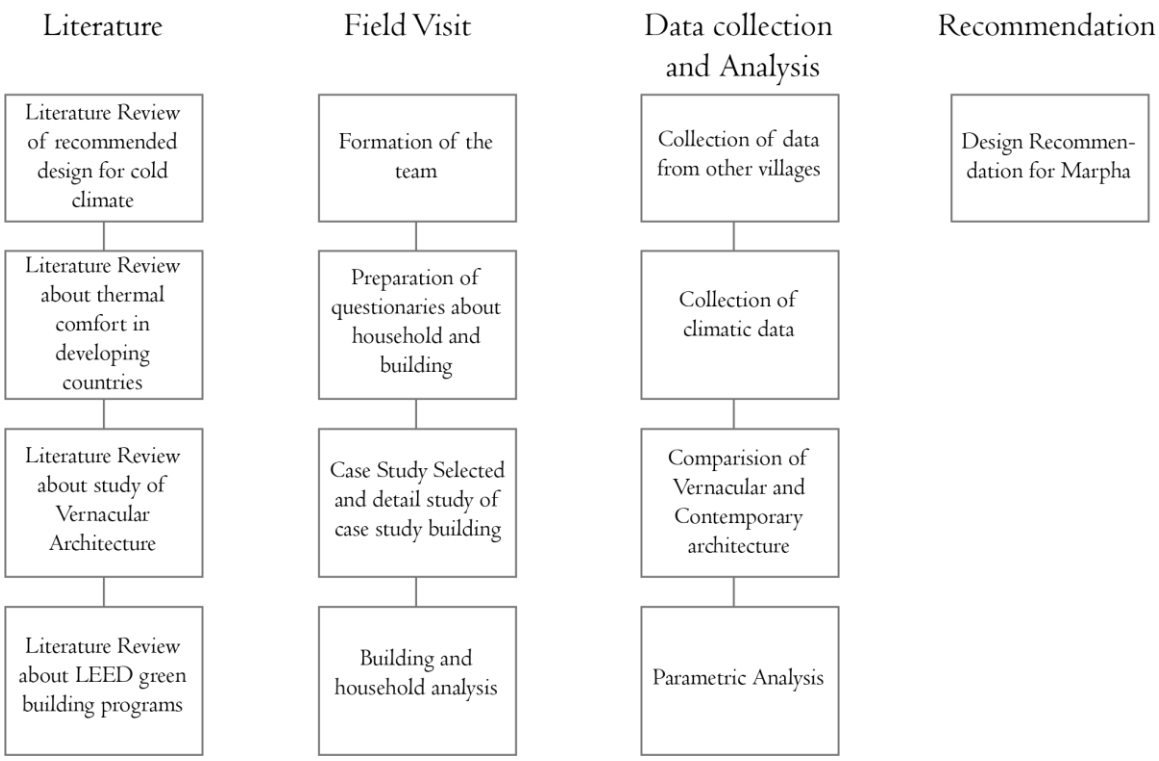


Figure 1: Methodology

LIMITATION

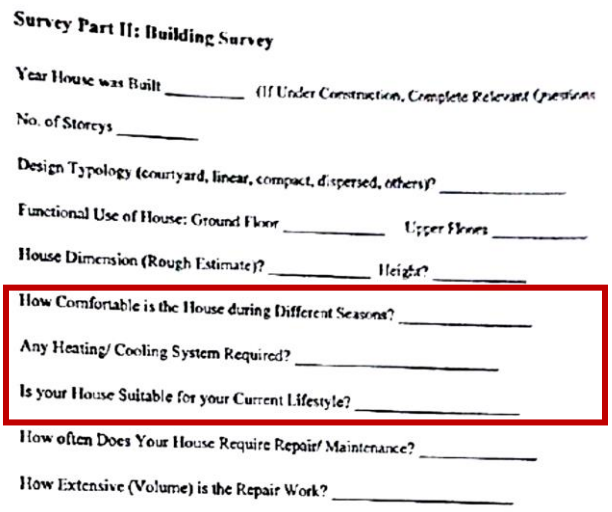
Since the research is in the underdeveloped country, there are few unexpected limitations that I faced during this research. Some of the limitations are listed below along with the description of I overcome them.

Lack of Climatic Data:

The climatic data of Mustang is not available in epw format. So, I collected the data from a different source: Government, online weather websites and Meteonorm software, complied them in the excel file and then created a epw format with the help of the software Element.

Lack of Thermal Comfort information:

The thermal comfort zone of the people varies from place to place and culture to culture. The lack of research regarding the comfort zone of the people living in the mountain region, it was difficult to conclude how people might experience in a certain condition. To overcome this limitation, the questionnaire regarding the comfort experience was prepared and asked the sample of people. With the collected data the comfort zone for the people living in the mountain region is analyzed.



Survey Part II: Building Survey

Year House was Built _____ (If Under Construction, Complete Relevant Questions

No. of Storeys _____

Design Typology (courtyard, linear, compact, dispersed, others)? _____

Functional Use of House: Ground Floor _____ Upper Floors _____

House Dimension (Rough Estimate)? _____ Height? _____

How Comfortable is the House during Different Seasons? _____

Any Heating/ Cooling System Required? _____

Is your House Suitable for your Current Lifestyle? _____

How often Does Your House Require Repair/ Maintenance? _____

How Extensive (Volume) is the Repair Work? _____

Figure 2: Sample of question about thermal comfort

Chapter 2: Understanding Mustang

Figure 3: Map of Marpha

'डाँडा पारीको गाउँ: The village behind the mountain', is the home for the thakali and Hindu people with unique culture, traditions, and language. Caught in the rain shadow of Dhaulagiri Himal (8167m) to the west and the Annapurna massif to the east, most of Mustang's 750 square miles are trans-Himalayan desert.[6]

From the cliffs dotted with caves that were once prehistoric dwellings to the ruins of century-old fortresses, Mustang is one of the interesting places in Nepal. Until 1992, Mustang was the forbidden kingdom and was isolated from the world. Even after that, only a few thousand people get a permit to visit mustang annually. It is very interesting to me, even though it just been 27 years since Mustang got exposure with the outer world, the culture, and architecture of this place has been already influenced.

Mustang District, a part of Dhaulagiri Zone, is one of the seventy-five districts of Nepal. The district, with Jomsom as its headquarters, covers an area of 3,573 km² and has a population (2011) of 13,452[7]. The Mustang district comprises the following 8 VDC's:

- Charang, Chhonhup, Chhoser, Chhusang
- Dhami

[6] *Susanne von der, H. (2000) 'Changes and Developments in Upper Mustang, Nepal: Decision making at the Local Level', Library of Tibetan Works and Archives, Vol. 25.*

[7] *"National Population and Housing Census 2011 (National Report)" (PDF). Central Bureau of Statistics. Archived from the original (PDF) on 2013-05-25.*

- **Jhong, Jomsom**
- Kagbeni, Kowang, Kunjo
- Lete, Lo Manthang
- **Marpha**
- Surkhang
- Tukuche

For this research two villages, Marpha and Jomsom of Mustang district have been taken for the study which lies in the lower part of the Mustang. Since Jomsom is the headquarter of Mustang, it is the highly influenced one with the modernism.

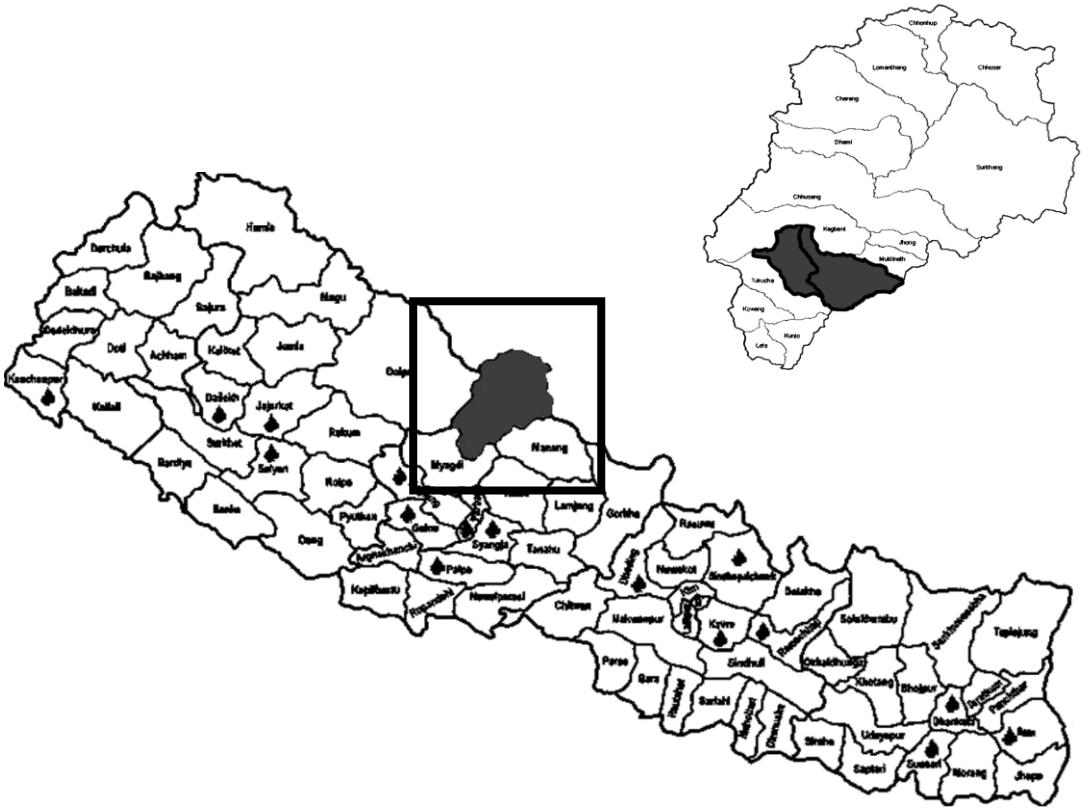


Figure 4: Map of Nepal showing Mustang, Marpha and Jomsom

GEOGRAPHIC LOCATION

Mustang lies in northern Nepal, with latitude and longitude 28.9985° N, 83.8473° E. The Marpha is a valley located just below the Nilgiri peaks to the east and Dhamphus and Tukuche peak to the west whereas Jomsom is located at the bank of Kali Gandaki river 4.3 miles away from the Marpha. The elevation ranges from 2100m in the southern part to 5400m, and above in the north. The high peaks rise up to 8168m. Most of the human settlement is found at 2100m to 4000m elevation along the Kali Gandaki River.[8]

The settlement of Marpha is in steeply slope and mountainous at elevation 2650m, whereas the settlement of Jomsom is located in the bank of the river at elevation 2,743 m.

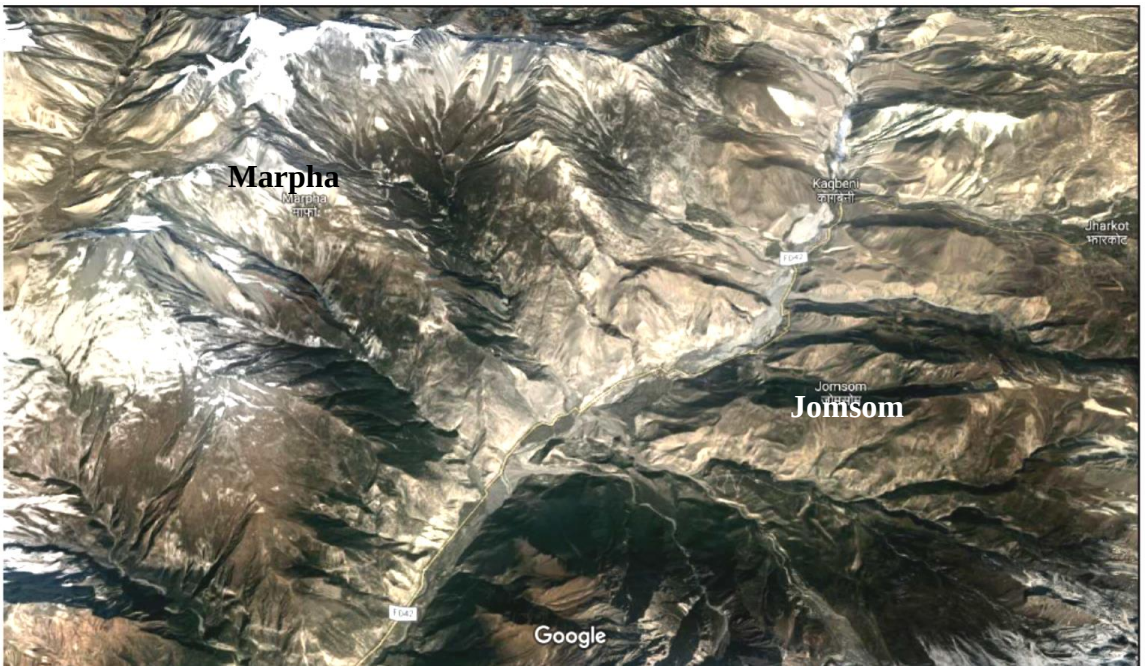


Figure 5: 3D map of Mustang showing Marpha and Jomsom

[8] *Asmita, D. et al. (2014) Marpha Settlement Study. Settlement Planning Course Report. Nepal Engineering College.*

HISTORY

Mustang once known as the kingdom of the Lo. has a unique history. The name Mustang is actually a Nepali misnomer for the Tibetan expressions Man thang (" sman thang") "plain of medicinal herbs," and Mon thang (" smon thang "), "plain of aspiration."[9] One day ride forms the Tibeto-Nepalese border, the capital Lo Man thang at the altitude of 3790m is located with the royal palaces and significant Buddhist monasteries from the 15th century with beautiful unique stone architecture. The inhabitants of the Mustang are related culturally to the Tibetan sphere of influence. The way of life, their script and their festivals and their religious belief are close to Tibetan Buddhism.[10]

After 1992, the former kingdom Mustang was made open to the foreigner, people of Mustang and government of Nepal are trying to build up an infrastructure. Along with the infrastructure, people and government are trying to save the unique culture and religion of Mustang from being swamped by foreign tourists. Even though tourism is the threat towards the history and the religion of that place, most of the people today is economically depended on tourism and they have a positive attitude towards the development of tourism.

"We must do our best possible effort to protect and preserve our natural resource and valuable cultural heritage with tourism" Junior Raja of Mustang Jigme S. P. Bista.[11]

The architecture of the Mustang is unique and diverse throughout the Mustang from caves to contemporary architecture we can today see varieties of architectural styles. In Marpha and Jomsom, three types of architecture can be seen exhibiting the history, culture and development of the place: The compact stone architecture with no courtyard, Compact Stone architecture with courtyards and contemporary RCC structure are three different

[9] *Susanne von der, H. (2000) 'Changes and Developments in Upper Mustang, Nepal: Decision making at the Local Level', Library of Tibetan Works and Archives, Vol. 25.*
[10] *Susanne von der, H. (2000) 'Changes and Developments in Upper Mustang, Nepal: Decision making at the Local Level', Library of Tibetan Works and Archives, Vol. 25.*
[11] *Susanne von der, H. (2000) 'Changes and Developments in Upper Mustang, Nepal: Decision making at the Local Level', Library of Tibetan Works and Archives, Vol. 25.*

types of architecture that we can see in Mustang today. The development of architecture is further explained in chapter three.

CLIMATE

Temperature:

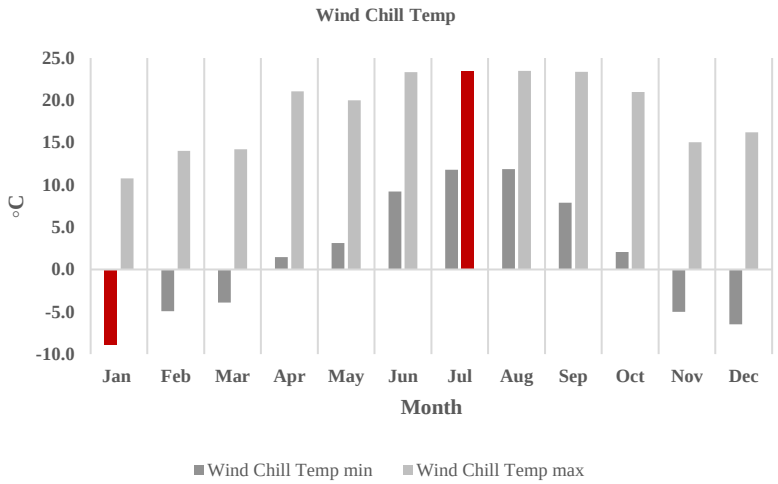
Due to the geographic location, the climate of Marpha and Jomsom is cold, dry and windy which make this place the only desert of Nepal. The coldest temperature of 2017 was around -9 ◦c while the hottest was 23.5 ◦c with the effect of wind as shown in the table below.

Table 1: Climatic Data of Marpha, Mustang, Source[12] [13]

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Min Temp (◦c)	-4	-1	0	4	5	10	12	12	9	5	-1	-2
Max Temp (◦c)	11	14	14	20	19	22	22	22	22	20	15	16
Rel. Humidity (%)	65.6	65.4	66.0	61.8	70.2	69.7	81.0	82.2	82.4	76.0	71.4	53.6
Rainfall (mm)	13.3	6.3	44.9	119.3	169.3	195.4	662.3	414.2	152.6	14.9	2.4	3.3
Days of Rain	-	3	19	18	26	27	31	31	22	14	3	3
Wind Speed (kmph)	5.5	6.2	5.4	5.3	4.7	5.5	4.6	4	5	5.8	7	6.9
Gust (kmph)	12.9	11.7	12.4	10	8	7.1	5.9	5.6	7.7	13	12	13.1
Wind Chill Temp min	-8.9	-4.9	-3.9	1.5	3.1	9.2	11.8	11.9	7.9	2.1	-5.0	-6.5
Wind Chill Temp max	10.8	14.0	14.2	21.1	20.0	23.3	23.4	23.5	23.4	21.0	15.0	16.2

[12] *World Weather Online (Accessed March 8, 2019). Available at: https://www.worldweatheronline.com/mustang-weather-averages/np.aspx.*
[13] *Government of Nepal, Ministry of Energy, Water Resources and Irrigation, Department Of Hydrology and Meteorology*

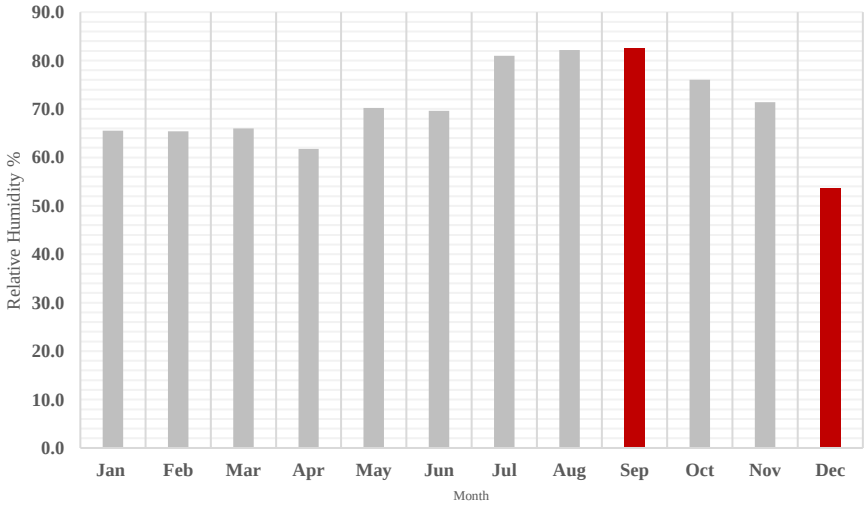
The following graph shows the highest and lowest wind chill temperature of Marpha, Mustang.



Graph 1: Showing wind chill temp. of Marpha, Mustang

Humidity:

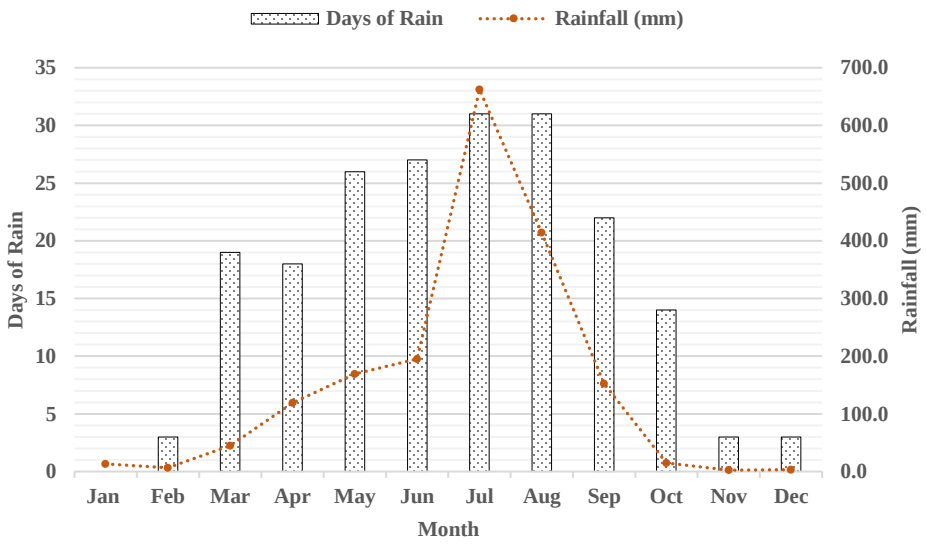
The maximum humidity was 82.2% and minimum humidity was 53.6% in 2017.



Graph 2: Showing Humidity of Marpha, Mustang in %

Rainfall:

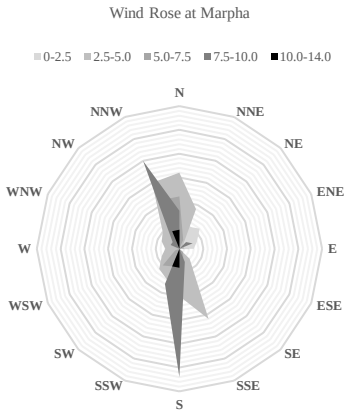
The Marpha, Mustang is known to be located at the rain shadow. The rainfall in this place is low. The maximum and minimum rainfall in 2017 was 662.3 mm and 0mm respectively as shown in the graph below.



Graph 3: Showing Rainfall data at Marpha

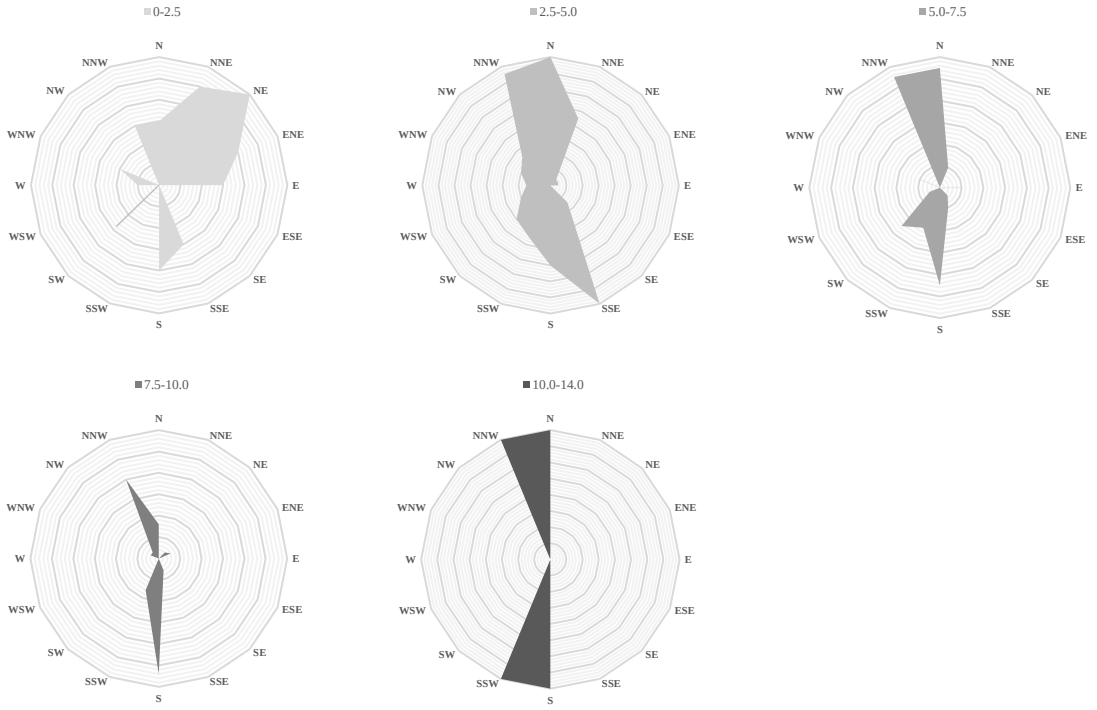
Wind:

Jomsom located in the high-altitude of 2700 m, is famous for its strong intensity of wind blowing through the afternoon. Not only in Jomsom, but the wind velocity is extensively high in Marpha with 12.4 kmph (7.7mph) wind speed. The wind direction is uncertain in this place but the maximum wind flow in a south-north direction.



Graph 4: Showing Wind Rose at Marpha

According to meteorological data, the strongest up valley winds were found between Marpha and Chuksang with typical speeds of 24-32 kmph (15-20 mph).



Graph 5: Showing Wind Rose at Marpha according to wind speed in mph

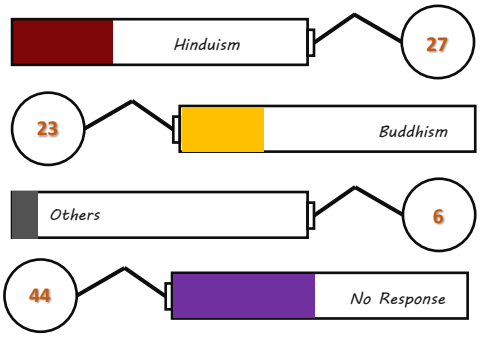
CULTURE

People:

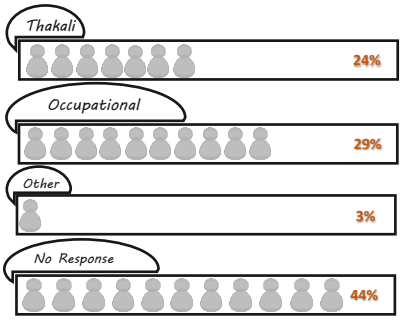
The Thakali group is the original ethnic group of Marpha who were once active in salt trade from Tibet and across the mountains in western Nepal. Religiously, we can see two groups of people in Marpha: Thakali and occupational group (Dalit). The Thakali people have Buddhist religion whereas Dalit people are either Hindu or Christian. Most people are Thakali who are wealthy and involve in business

Figure 6: People of Marpha
Source: https://www.flickr.com/photos/markdionne/5281353152/

either in tourism or in the trading. The dalit people are economically challenged and work either in agriculture or for Thakali people.



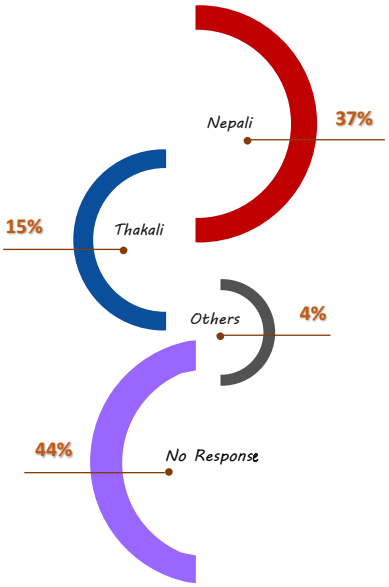
Graph 6: Showing percentage of religion



Graph 7: Showing percentage of caste distribution

As the major tribes of Marpha or to be precise of Mustang, are descendants from Tibet, the people follow Tibetan Buddhist culture. On the southern outskirts of Marpha, on the opposite bank of the Gandaki River is a Tibetan refugee camp, a school and Chhairo gompa, the first Nyingma monastery to be established in Mustang District. Many of the souvenir shops in Marpha are run by residents of the Tibetan refugee camp. [14]

According to our survey conducted on 2015 out of 210 people, 27% were found to be following Hinduism, 23% followed Buddhism, 6% were from other religion and 44% did not respond. All the Thakali we surveyed were Buddhist and most of the occupational groups were Hindu. Few among 3% from the occupational group followed Christianity.



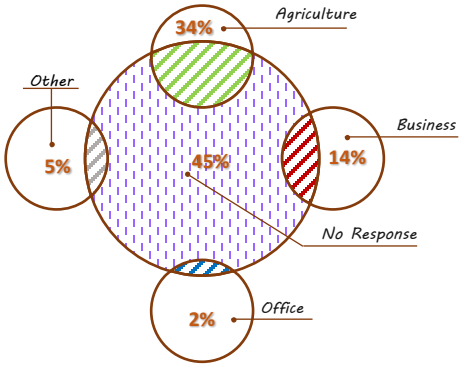
Graph 8: Showing percentage of people speaking different languages

According to the survey, 37% spoke Nepali, 15% spoke thakali, 4% spoke another language whereas 44%

[14] *Asmita, D. et al. (2014) Marpha Settlement Study. Settlement Planning Course Report. Nepal Engineering College.*

did not respond. The total population of overall Marpha village was 401 with male 208 and female 194 in 2015.[15]

Occupation:



Graph 9: Showing percentage of Occupation

The major occupation of people of Marpha is business mostly tourism while others are involved in agriculture and government office work. According to the quantitative survey, it was found that most of the family are occupationally based on Agriculture. Since Marpha is touristic area Business like Hotel, shops were the second priority of people over there. Mainly the houses on the primary road are doing business while others are based on agriculture. Some people are doing a job in the office like the village development committee office, woman health center, post box office, etc. People were also involved in an occupation like making utensils, making cloths, factory, taking care of other's cowshed, etc.

Family:

Families in eastern countries like Nepal, people always live with their parents. Similarly, in Marpha, people especially son always live with their parents while the daughter gets married and then live with their husband's family. So, according to the culture and the literature, the families in Marpha are predicted to be mostly joint families with grandparents, parents, and children. In some cases, families of brothers also live together with a large joint family. The culture of living with family is one of the significant cultures in an eastern society which drives different other cultures of the society.

Figure 7: Children of Marpha
Source: http://elevation.maplogs.com/poi/marpha_nepal.167523.html

[15] *Asmita, D. et al. (2014) Marpha Settlement Study. Settlement Planning Course Report. Nepal Engineering College.*

According to the survey, contradicting the expectation, most of the families in the village were found to be nuclear. 53% of people refused to answer our survey while out of 47%, 40% of the total household were nuclear family and only 7% were joint. Our study shows that migration was the reason for the increase in the nuclear family. Because of the migration of new generation towards town or foreign countries, only parents are forced to live alone despite the joint family culture of the society.

Among our population distribution, 56% of people were working group while 5% population were not working. 6% population were going to college and 24 % were school children while 9% were an infant. Most of the children from Thakali attends school at Jana Jyoti high school at Jomsom. Occupational group children attend Jana Bal, the government school at Marpha. Few children from the Thakali community has also attended Jana Bal. Since Jana Bal is only up to class 10, children from occupational group, which cannot afford to migrate are deprived of higher studies.[16]

Lifestyle:

Figure 8: Women at old settlement of Marpha eating apple in her traditional dress

[16] *Asmita, D. et al. (2014) Marpha Settlement Study. Settlement Planning Course Report. Nepal Engineering College*

The lifestyle of people in the Marpha is simple. The whole village is compact, and people live like a big family. Everyone knows each other. They celebrate festivals together. The archery festival is one of the famous festivals that bring people together. The whole village is in walkable distance and everything is connected in the village.

Most people live and work on the same building decreasing their daily travel time. Unlike another part of Nepal, both male and female go to work but most of the household chores are handled by women in the house. One of the famous things about Marpha is the alcohol made of apple. Most of the people over there might be drunk most of the time because of the famous alcohol and the cold weather.

Figure 9: Local people of Marpha in front local shop
Source: https://english.onlinekhabar.com/400232.html

The old generation of people wears traditional dresses whereas the young generation of people wears a modern dress like jackets and pants. People used to be uneducated before, but now most young people go to school or college in the nearby city. The lifestyle of people of Marpha is simple and ground to earth in general.

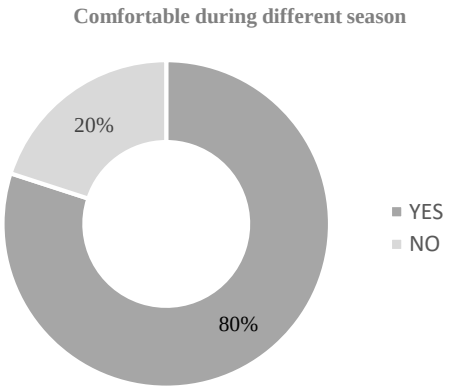
Thermal Comfort:

We all know that the thermal comfort of people varies according to their lifestyle, place they grew up and the experience with the climate. The people living in the mountain region has more tolerance to the cold weather than the people living in the hot climate. Similarly, people from developed countries have a certain comfort zone which varies from people from developing or underdeveloped countries. According to the Baruch Givoni, the comfort zone for the developed countries is between 20-27◦c while for the developing countries its 18-29◦c.

The way people have been living helps to determine the comfort zone for people in that area. To understand the comfort zone of the people living in the Marpha, numbers of literature reviews were done. Our survey about this topic focused on how people living in vernacular architecture are feeling in term of comfort since these buildings are free-running and do not have any heating facility. Couples of questions were asked to the people regarding the comfort and their response was analyzed. Following three questions were asked to people:

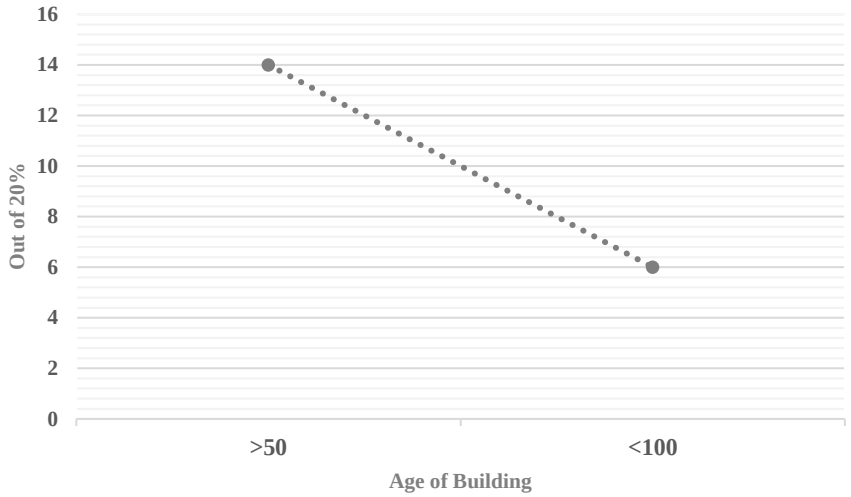
1. *Is your house comfortable during different seasons?*
2. *Any heating/cooling system required?*
3. *Is your house suitable for your current lifestyle?*

The collected data supported the hypothesis that the people over there feel comfortable even though they are living in a free-running building without any heating facility. Most of the people responded they feel comfortable, but it will be good to have the heating support.



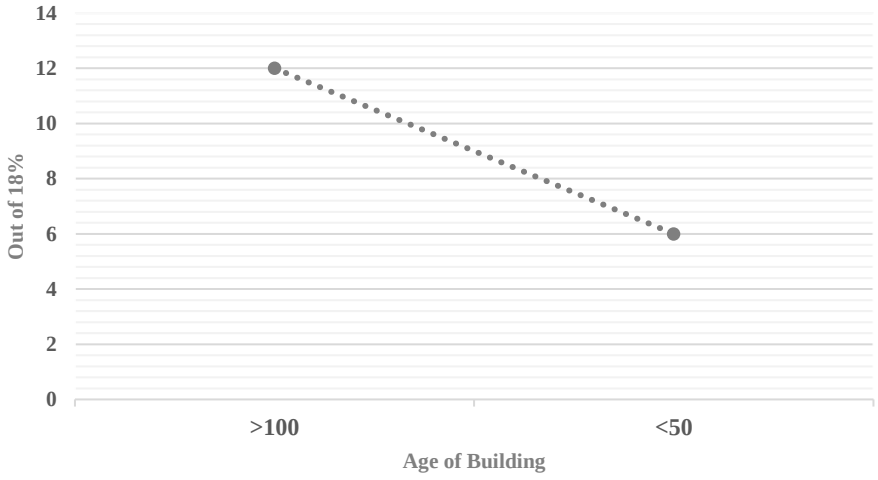
Graph 10: Showing people's response for comfort

Some of the people responded that they don't feel comfortable and when we cross analyzed the data with the age of the building it was really a surprise to see that most of them were from the building with less than 50 years of age. Out of 20% of people who responded they don't feel comfortable, 14% lives in building less than 50 years old while 6% lives in the building more than 100 years old.



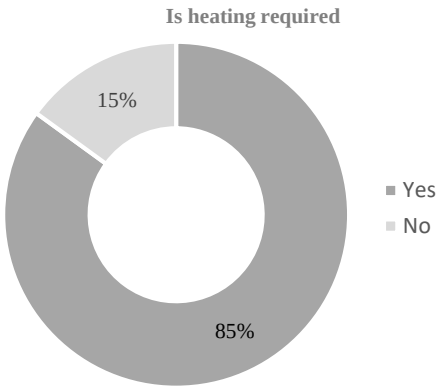
Graph 11: Showing comparison between percentage of response "Does not feel Comfortable" and age of building

Similar data was gathered when we asked people about “Is your house suitable for your current lifestyle?” Out of people who responded, 82% of people responded that the building was suitable for their current lifestyle while rest responded that it was not.



Graph 12: Showing comparison between percentage of response "Is your house Suitable for current lifestyle" and age of building

Most of the people who responded ‘No’ lived vernacular architecture, which is because of the change in culture and the lifestyle. Even though there is a change in culture and lifestyle, 82% of people responded that their house was suitable for their current lifestyle which was also surprising data for us.



Graph 13: Showing people's response for heating requirement

When we asked people if they need any heating/cooling system in their home, 85% responded yes, they need a heating system and 15% responded no. Most of the people said that they use coal for the heating purpose. When we were on the village, we saw that people used to light the coal outside the home and leave it at the road near their entrance and took same coal once the fire is low enough to take inside the home. This activity serves two purposes, one it makes coal ready to take inside home as well as it helps to warm the road up giving nice light in the dark.

STORY THAT I LIKE TO SHARE: WHY MARPHA? WHY JOMSOM?

I will never forget the day I visited Marpha, Mustang. It was the most dangerous road trip I had in my life. At one point, I was looking out of the window from the bus and I saw one rear wheel of the bus, literally hanging out in the cliff. The geography of the mountain region is challenging, and the political situation of Mustang make it even more challenging for the development.

Marpha is particularly interesting for me because of its unique whitewashed stone architecture perfectly clustered with each other forming a compact settlement. It looks like the whole settlement is one big family, supporting each other through rough weather to the deadly earthquakes.

When I reached Marpha, it was already evening. I was staying in the hotel half a mile away from the old settlement of Marpha. So, I decided to walk to the community and see around. But the weather was challenging. It was colder than I was used to living in, and the wind was making everything worse. I knew Mustang as a village in rain shadow, so I

wasn’t expecting any rain but due to the climate change rain in Mustang was not so uncommon. With cold, wind and rain, I was walking towards the village. At one point it was so windy that I had to walk backward because the wind wasn’t letting me see anything and move forward. Finally, I reached inside the community and one thing I realized as soon as I got inside was, I was not feeling any of the bitter weather outside. It was calm, silent and cozy.

That was the moment when I realized, what that community has, is something we need to create today, as an architect or urban planner. We are so dependent on technology today that the problem that we could solve through form, composition and simple physics is overlooked and never approached. In modern-day construction, we are too focused on maximizing the profit, simultaneously, creating new problems like urban heat island, coz gas emission, global warming, and climate change.

The second day in Mustang, I went to see Jomsom, headquarter of Mustang. I was so impressed by the architecture and settlement of Marpha that my expectation for Jomsom was so high. Since Jomsom is a famous tourist destination in Nepal, I was expecting to see something historical and preserved environment. But it wasn’t what I had expected at all.

The first thing I realized was the RCC construction of one residential building going on. The roads are wide and paved. Most of the buildings on either side of the road with hotels and restaurants are concrete structures. Even the dress of people and the way they live was modernized and different from Marpha. It was really surprising to see such a difference in the same place within 7 km (4.3 miles).

Jomsom is divided by river as New Jomsom and Old Jomsom. The old Jomsom is like Marpha, a clustered settlement with stone architecture. But the whole Jomsom is so much influenced that people living in new Jomsom with all the modern stuff are considered modernized and wealthy. The economic inequality and pressure of maintaining status in the society, people are encouraged towards this change without knowing the environmental consequences of the change in settlement pattern, architecture style, and construction method.

Changes are part of development. Being an architect, I appreciate and welcome any changes, but I believe any changes that we make should have a positive impact on the society and environment. If old is better, then changing in the wrong direction is not smart. The purpose of researching in Jomsom and Marpha is to analyze how vernacular approaches that we can see in Marpha were and what changes we are making in Jomsom, analyzing both with the environmental point of view and making a conclusion of either we are developing in a better way or not and if not, then what is the right direction of development.

CHANGING LANDSCAPE OF MUSTANG

Changing Culture of Marpha and Jomsom:

The change is culture is an important change in the community that impacts significantly on the settlement pattern and the architecture. How people live, talk, what they eat, how they dress, how they behave with each other, etc. impact the way of our lifestyle. Similar to most of the part of Nepal, people of Marpha and the culture is changing from traditional to modern. The people are more educated and exposed to the modern world and the technologies which develop different attitude and culture in people. The tourism business and migration are two main factors that stimulated the change in the culture in the Mustang. In Figure 10[17] and Figure

Figure 11: Children of Marpha

Figure 10: People of Marpha few years before

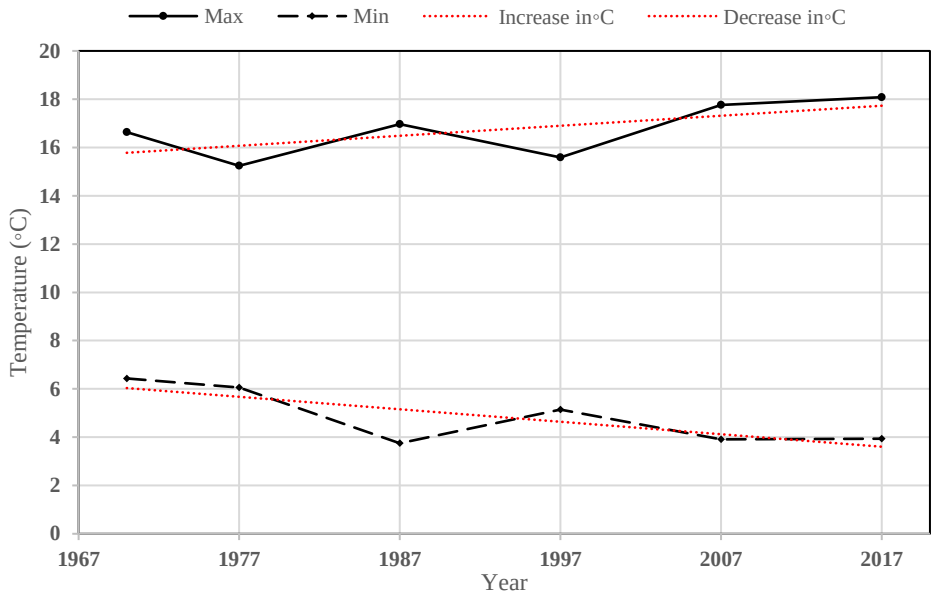
[17] *http://www.nepal-dia.de/int__England/EV_Annapurna/ENAT-60-2_Marpha/body_enat-60-2_marpha.html*

11[18], we can see the simple change in how people used to dress and how they dress today which impact in the comfort zone of the people. There are a different small and big cultural change in the society which influences the architecture and the settlement which is further discussed in chapter 5.

Changing Climate of Marpha and Jomsom:

We all are aware of the climate change but in the LDC like Nepal few numbers of research has been done to understand the impact of climate change especially in the mountain region. Mustang despite being the small part of the LDC is also affected by climate change resulting in the change of architecture, culture and the settlement in whole.

Mountain regions are considered as being one of the most fragile ecosystems and highly exposed to climate variability which can make livelihoods vulnerable. Despite this, little attention is paid to the vulnerability of mountain livelihoods (ICIMOD, 2010).[19]



Graph 14:Showing average max and min temperature at Marpha

[18] *http://marphafoundation.org/about/*
[19] *Renske, D. (2011) Vulnerability of livelihoods in Kagbeni Mustang district, Nepal. Master Thesis. University Utrecht, Human Geography.*

The temperature of Marpha and Jomsom are changing in a certain pattern. When the data of temperature[20] over 50 years in the interval of 10 years are plotted and analyzed it is found that, the temperature during winter (January) is getting colder than before whereas the temperature of October is getting hotter as shown in the graph below.

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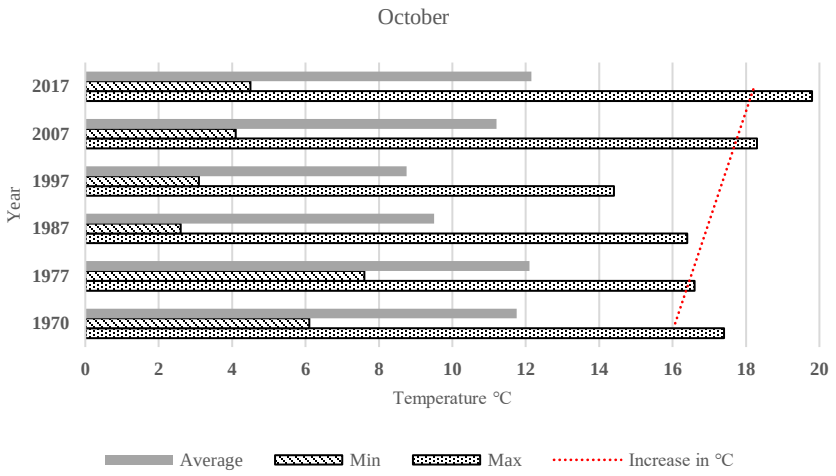
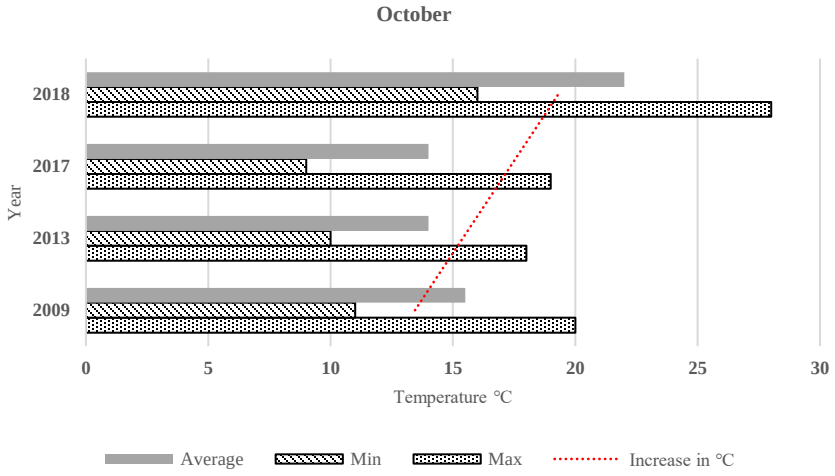


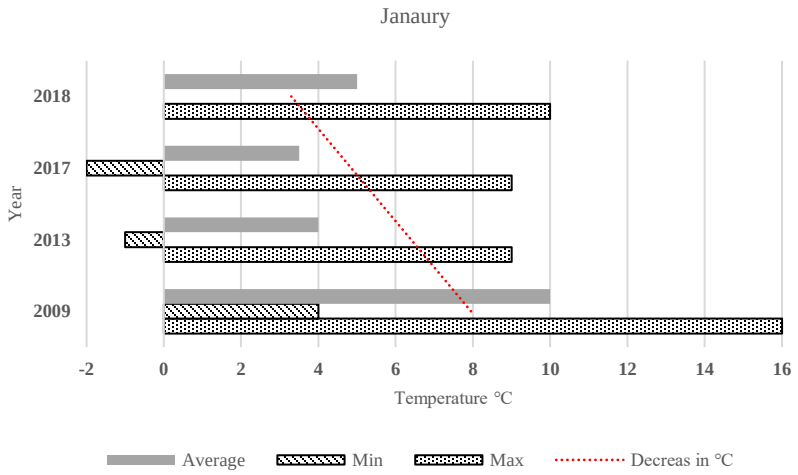
Graph 15: Showing temperature of 50 years in each 10-year interval at Marpha



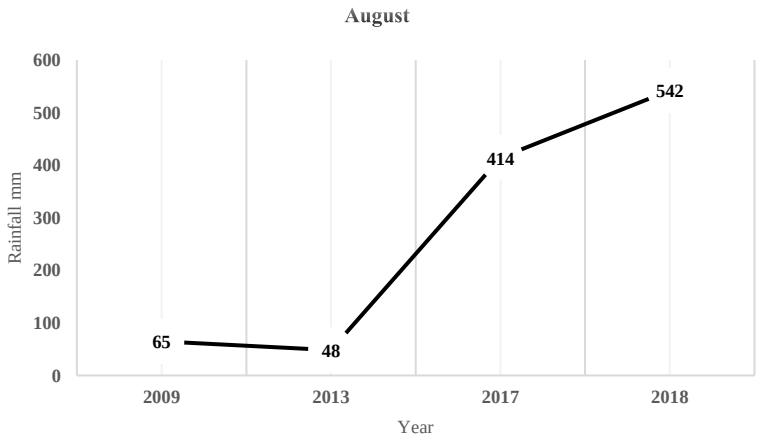
Graph 16: Showing temperature of 10 years in each 4 years interval at Marpha

[20] *Government of Nepal, Ministry of Energy, Water Resources and Irrigation, Department Of Hydrology and Meteorology*

To understand the current climate pattern of Marpha and Jomsom, the data of the past 10 years[21] was also analyzed and the graph below confirms the temperature of winter getting colder and summer getting hotter. We can also conclude that the climate is changing rapidly in the past few years more than before.



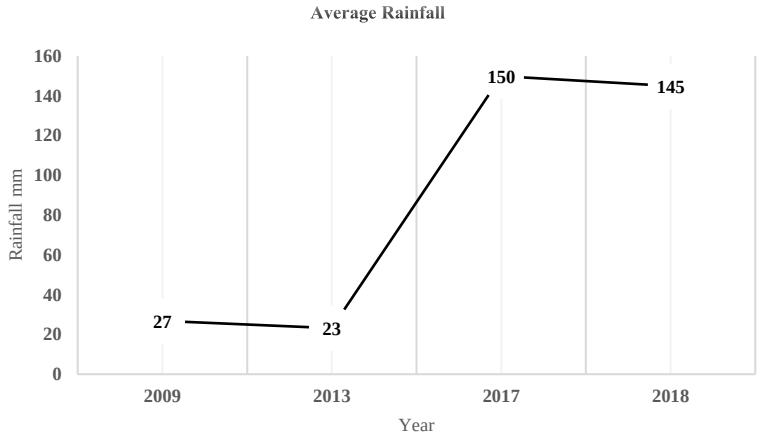
Graph 18 Showing temperature of 10 years in each 4 years interval at Marpha during winter



Graph 17: Showing change in rainfall during rainy season at Marpha

[21] *World Weather Online (Accessed March 8, 2019). Available at: https://www.worldweatheronline.com/mustang-weather-averages/np.aspx*

The rainfall in Marpha and Jomsom is a major change in the climate. The place once consider as in rain shadow has rainfall more than half a year (204 days in 2017). The rainfall data[22] for 10 years at Marpha shows that since 2009 there have been distinguished change as shown in the figure below.[23]



Graph 19: Showing change in average rainfall at Marpha

Rainfall is one of the main issues of Marpha and Jomsom because the vernacular architecture does not consider this factor and does not have a damp-proof layer. The architectural style with courtyard creates a huge problem when there is rain and none of the material or the construction has water resistance property. Most of the buildings hence has started to cover their courtyard and change them to atrium space. Changing courtyard into atrium might solve a problem of rain but during cold weather, there is now a problem of low heat gain since the settlement is too compact to gain heat from another surface. This change in temperature and rainfall shows that we need to change the architectural style to create a comfortable environment.

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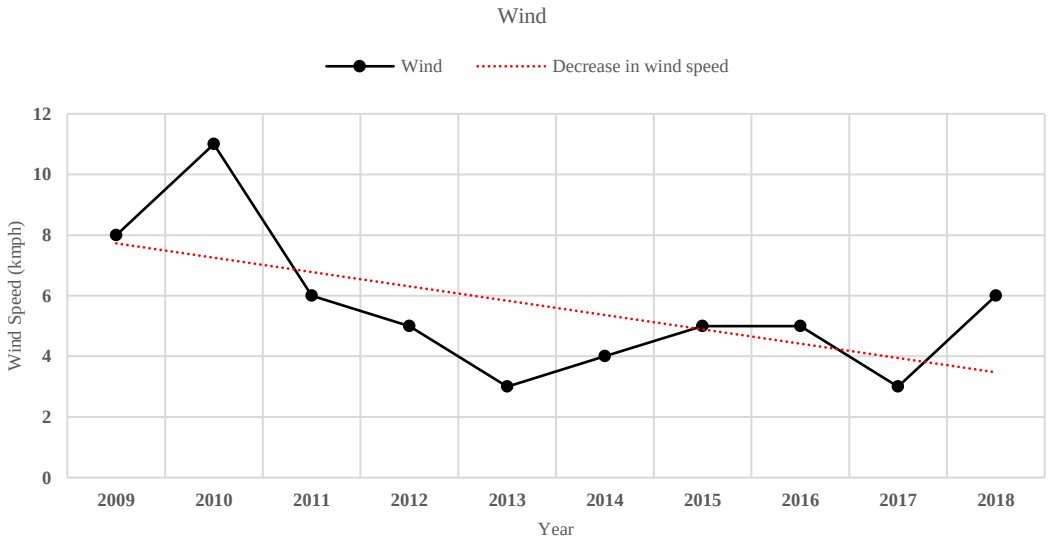
[22] *World Weather Online (Accessed March 8, 2019). Available at: https://www.worldweatheronline.com/mustang-weather-averages/np.aspx*

[23] *Government of Nepal, Ministry of Energy, Water Resources and Irrigation, Department Of Hydrology and Meteorology*

Rural communities are finding different measures to cope adapt to be able to sustain and reduce risk to climate change factors (Lama and Devkota, 2009)[24]. The change in the architecture of Marpha and Jomsom is also one of the ways of sustaining climate change. However, climate change also has a positive influence in this place. The agriculture specially the apple farming has been increasingly favorable over last decennia.[25]



Graph 20: Change in wind speed

Change in Architectural Style and Construction Practice:

"The climate and culture are changing so must the architecture."

Building construction methods have changed greatly in the last two or three decades, and modern designers often choose to ignore fundamental aspects such as climate.[26] Even

[24] Renske, D. (2011) Vulnerability of livelihoods in Kagbeni Mustang district, Nepal. Master Thesis. University Utrecht, Human Geography.
[25] Renske, D. (2011) Vulnerability of livelihoods in Kagbeni Mustang district, Nepal. Master Thesis. University Utrecht, Human Geography.
[26] Anir kumar, U., Hom Bahadur, R. and Harunori, Y. (2006) 'Climate Responsive Building Design in the Kathmandu Valley', Article in Journal of Asian Architecture and Building Engineering.

though the author was talking about the Kathmandu Valley in his journal, this is a fact not only in Kathmandu valley but also in all other developing parts of Nepal. The construction practice of Mustang has also been changed from stone-mud to the concrete-steel.

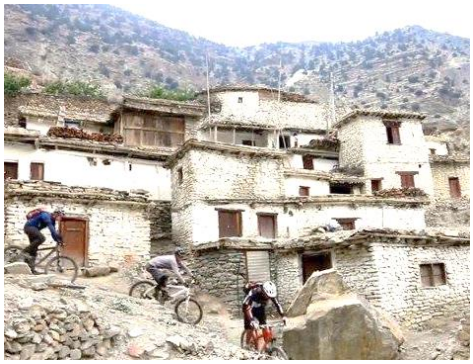


Figure 12: Vernacular Architecture and Compact Settlement

"Mud has an unlimited life, but cement lasts only fifty to sixty years. That's why we have seven-hundred-year-old monasteries," says Lama Ngawang.27

With the introduction of new material and construction practice, the iconic packed whitewashed stone architecture of Mustang is slowly being replaced by the concrete-steel structures, changing the unique identity of Mustang.

From the graph below, [28] [29] we can see the change in the architectural style in Marpha and Jomsom. Out of 70 buildings, 62 were vernacular and 8 were modern at Marpha, 42 were vernacular and 28 were modern at Old Jomsom whereas at New Jomsom, 29 were vernacular and 41 were modern. We can see the influence and change in Jomsom are high and the influence in Marpha has been started.

Figure 13: Modern Architecture

[27] *Nina, W. (Accessed on 07 March 2019) Modernizing Mustang: A Hidden Tibetan Kingdom Meets Its Future, Global Oneness Project. Available at: https://www.globalonenessproject.org/library/articles/modernizing-mustang-hidden-tibetan-kingdom-meets-its-future.*
[28] *Raj Kumar, K. et al. (2014) Jomsom Settlement Study. Settlement Planning Course Report. Nepal Engineering College.*
[29] *Asmita, D. et al. (2014) Marpha Settlement Study. Settlement Planning Course Report. Nepal Engineering College.*

Graph 21: Showing number of houses in different architectural styles

Chapter 3: Settlement of Marpha and Jomsom

The traditional settlement pattern of both Marpha and Jomsom were compact with buildings built with local materials, narrow roads, dense settlement, proper water, and drainage system. In this chapter, the settlement of the Marpha and Jomsom is explained in term infrastructure. To understand the village and its sustainability it is important to understand the village as a whole, not only one building. We can never achieve sustainability with one building. The sustainability of the society as a whole is necessary.

To understand the settlement and the change in the settlement both villages, Marpha and Jomsom are studied. By the study of Marpha with the traditional settlement character and the Jomsom with the modern changes, I tried to compare and analyze both.

Figure 14: Showing new and old settlement of Jomsom

ROAD

The road is one of the important infrastructures. 37 km long BENI-JOMSOM highway is the only road connecting Marpha and Jomsom. Though the highway pass by these villages, highway does not cross Marpha and Jomsom. All these Villages have their own stone-paved secondary and tertiary roads. Hence roads of Mustang can be categories into two divisions:

1. BENI-JOMSOM highway

2. Inner-Village Road.

Before the construction of Beni-Jomsom Highway, means of transportation was either walking or horse ride. 1-week walking distance from Marpha to Beni is subtracted to 1-day travel distance by this highway. 12m wide, unpaved highway start from Beni to Upper Mustang. The drainage channel passes at the right of the highway and the highway also serves the electric pole to pass on its right side at a certain interval. The advantages and disadvantage highway lead to the village and people over there is a list about below:

Advantages: 1. Shorten the distance between the village and Beni Sahara. 2. Increase possibilities of trade and marketing. 3. Enhance other infrastructures in the village. 4. Increase people in the village.

Disadvantages: 1. Discourage the tourist, as highway replaces the trek route. 2. Noise and environment pollution. 3. Damage agriculture and health due to dust and dirt. 4. Increase out-migration.

Marpha:

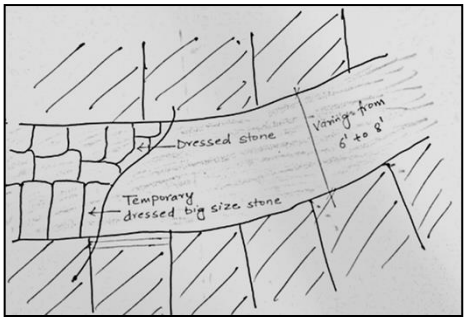


Figure 15: Sketch of primary road of Marpha

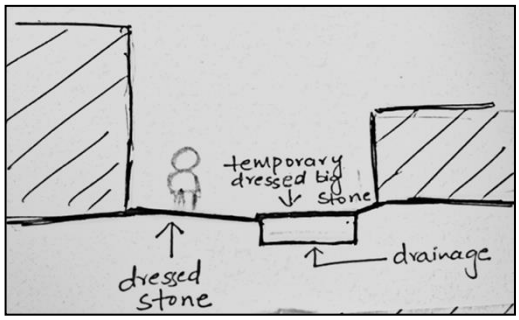


Figure 16:Section of primary road of Marpha

Curve Marpha Road is paved with flagstone. The Marpha road leaves the Beni-Jomsom Highway and passes through the village and re-joins with the highway at the end

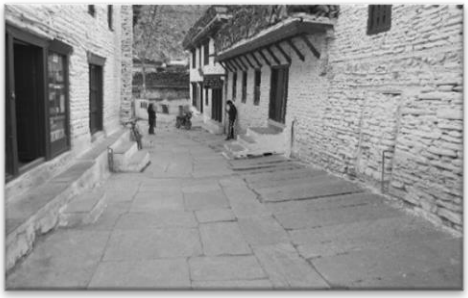


Figure 17:Primary Road

Figure 18: Secondary Road

of the village. Houses are arranged at either side of the road. The width of the road varies from 6' to 8' depending on the topography of the place. The road inside the village can be divided as a primary, secondary and tertiary road. Primary roads are the main roads with hotels and shops on either side. Secondary roads are smaller than primary road and these roads contain houses on either side. The tertiary road connects the secondary road and is very narrow. Primary and secondary roads are paved with dressed flagstone. The tertiary road is not paved. Primary road has big flagstone in its right side beneath which the drainage of the overall village is set-up. The big size stone is placed as a covering of drainage channel. Big size stone is placed so that it can't be misplaced easily.

Figure 19: Tertiary Road

Jomsom:

The Jomsom can be divided into Old New Jomsom based on the infrastructure, building types and the facilities available. New Jomsom locating at Marpha VDC road structure differ from the Old Jomsom of Jomsom VDC. The government office area also has different road structure. So, the road of Jomsom can be divided into three types according to the location. Road of New Jomsom is much wider and managed than the road of Old Jomsom. 24' wide (8m) road of New Jomsom is a vehicular road with streetlamp and proper drainage facilities. 2m in either side is a footpath and 4m in the center is the vehicular road. The footpath is dressed regular stone-paved while the vehicular road is undressed irregular stone-paved. The streetlamp is placed at 40' interval. The buildings along the road are a hotel, shops, and business orientated. Road of the area where government offices are situated has well managed and planned road structure. The road of that area is 28' wide with footpath, green belt, and vehicular zone separated.

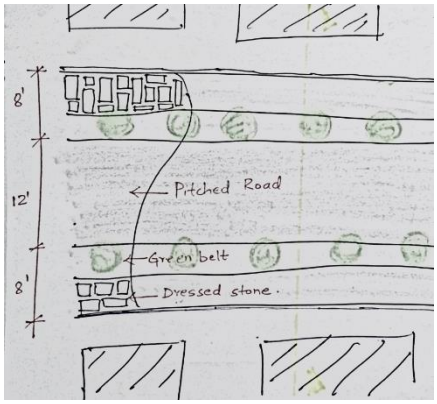


Figure 20:Sketch of road at government office, New Jomsom

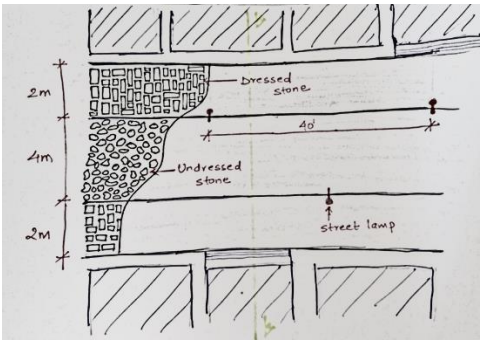


Figure 21: Sketch of primary road of Jomsom

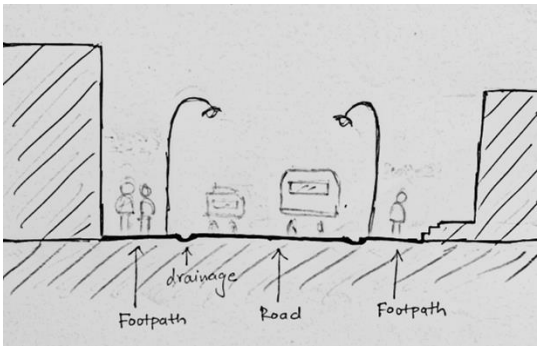


Figure 22:Section of primary road of Jomsom

Figure 23: Road at government office

Figure 24:Road at New Jomsom

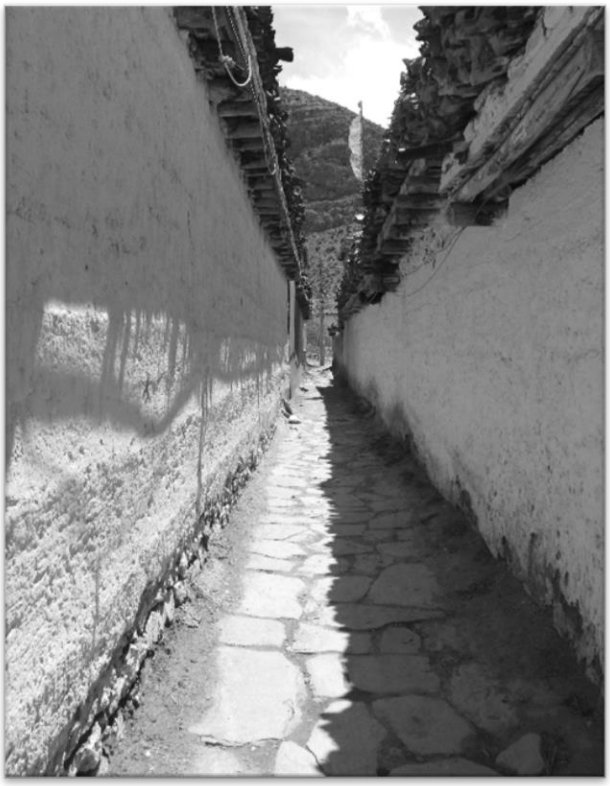


Figure 25: Road at Old Jomsom

STREET PATTERN

Marpha:

One of the identities of Marpha village is curved streets. Because of the organic street pattern, the wind speed is blocked and thus it feels warm when inside the village. The stone-paved historical street patterns which once created vibrancy for trekkers and tourists is equally adopted to bikes at present. But the road is quite narrow for vehicular access.

Figure 26: Street Pattern of Marpha

Jomsom:

The major street in New Jomsom is as big as the two-way vehicle can access easily. The settlement has grown on either side of the street. After crossing the bridge, the street pattern in the old Jomsom is again articulate pattern. Thought the old Jomsom is articulate pattern, it is somehow straight and linear. The road of Jomsom lacks the curviness.

Figure 27: Street Pattern of Old and New Jomsom

As shown in Figure 26: Street Pattern of Marpha Figure 26 and Figure 27, the settlement can be clearly seen to be changing from compact to the linear form. It is very interesting for me because the street pattern in these places plays an important role to avoid the wind. But due to different factors like tourism, road, culture, development, etc, the whole pattern and the settlement can be seen changing.

WATER SUPPLY

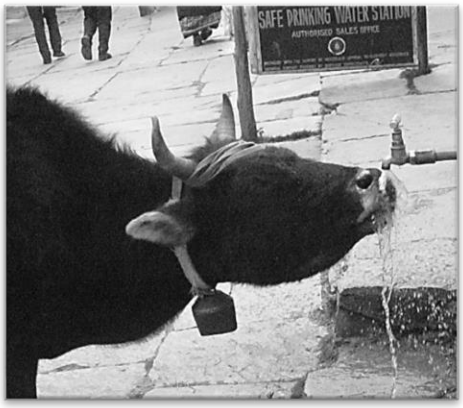


Figure 28: Water supply

Water supply in Marpha is very good. Almost all house has water supply and taps along with community taps spread throughout the village. Source of water in Marpha is from Pom Kyu, a small river flowing into the Kali Gandaki only a short distance north of the village. The source of Pom Kyu is at high altitude near-permanent snow and ice fields. Locals responded that they have no problem of water supply for daily use even in the dry season. But they complained that due to rain, water is contaminated for sometimes. The water system in Jomsom is also similar type. Each house is well facilitated with water tap inside their house and community tap in different locations around the village.

ELECTRICITY

Electricity in Marpha and Jomsom is from "Chokhopani hydropower". It was established on 2041, Magh 18[30] from the hands of Late King Birendra Bir Bikram Shah. While most of the part of Nepal was struggling with the load shedding problem there was no problem of load shedding in lower Mustang due to hydropower at chokhopani which produces 240KW electricity. 500KW electricity is provided from the zone level. During the load shedding scheduled by zone level, 240 KW is provided from the local hydropower which reduces the load shedding problem in Marpha, Jomsom and other parts of Muktinath.

In Tukuche, there is new hydropower which is being implanted to generate 13.5kw electricity which will resolve the problem of electricity in that zone. Tukuche is 2km far

[30] Nepali Date

away from Chokhopani. In Marpha, all buildings were connected to the electricity grid except one. The house is in the occupational group and has single-member. He used an oil lamp. Use of electricity is more in Jomsom than in Marpha. The electric pole is found on the line of the main highway that goes to Jomsom. Not only the main highway but the electric poles run through the village as well, which is a threat. In these compact settlements, where buildings are attached and connected to each other are in risk of spreading fire due to short circuit.

DRAINAGE SYSTEM

The drainage system can be categories into two type: Individual Household Drainage System Overall Village Drainage System

Individual Household Drainage System:

Figure 29: Showing individual drainage

In Marpha, and Jomsom village, individual vernacular houses lack the proper drainage system. The roof is constructed of stone with mud finishing which creates the muddy roof during rain and snow. Flat roofs collect snow and people must manually dispose of those snow collected. In Marpha, houses built back 10-20 years have tried to solve the problem of drainage by placing the drainage point in the roof while the houses built back 50->100 years is still facing the problem. Jomsom can be divided into a new and old settlement. Since Jomsom is a touristic area, construction technology is new with a solved drainage system in the new settlement. Roof with drainage points and projected pipes can be seen in the new settlement of Jomsom. While in the old settlement, the drainage channels are found in each old and new house. In a conversation with Rajani Sherchan, teacher of high school in Jomsom, there used to be drainage channel made up of wood in each house to drain the water due to snow, but now even in her own house she had

re-constructed and replaced that wooden channel with PVC pipes. Still, in old houses, the wooden drainage channels can be seen which are been drained out to the river.

Overall Village Drainage System:

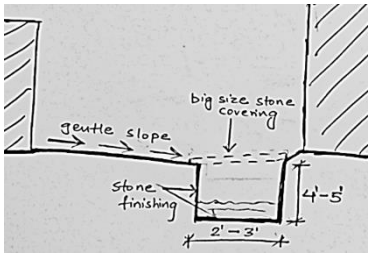


Figure 30: Sketch of road showing drainage

In Marpha village, the overall village has an impressive way to drain out the rain and snow water. Since the topography of the village is sloppy, water just needs to be properly guided to flow down. From the historic age, water itself had created its way to flow down towards the river. The people of Marpha village have respected nature and did not disturb the channel, instead, they left spaces for water movement. The movement of water in place of the road is beneath it. The temporary big size stone is placed on the right side of the road so that if any repair is to be done road should not be damage.

Figure 31:Drainage under road

In Jomsom, wide road of 8m is divided into 2m wide footpath in either side. The footpath is sloped down towards the road and the small channel is created in between for the movement of water. Manholes are placed in a certain interval for maintenance. In place of speed breaker, small drainage points are provided.

SEWAGE AND SOLID WASTE DISPOSAL

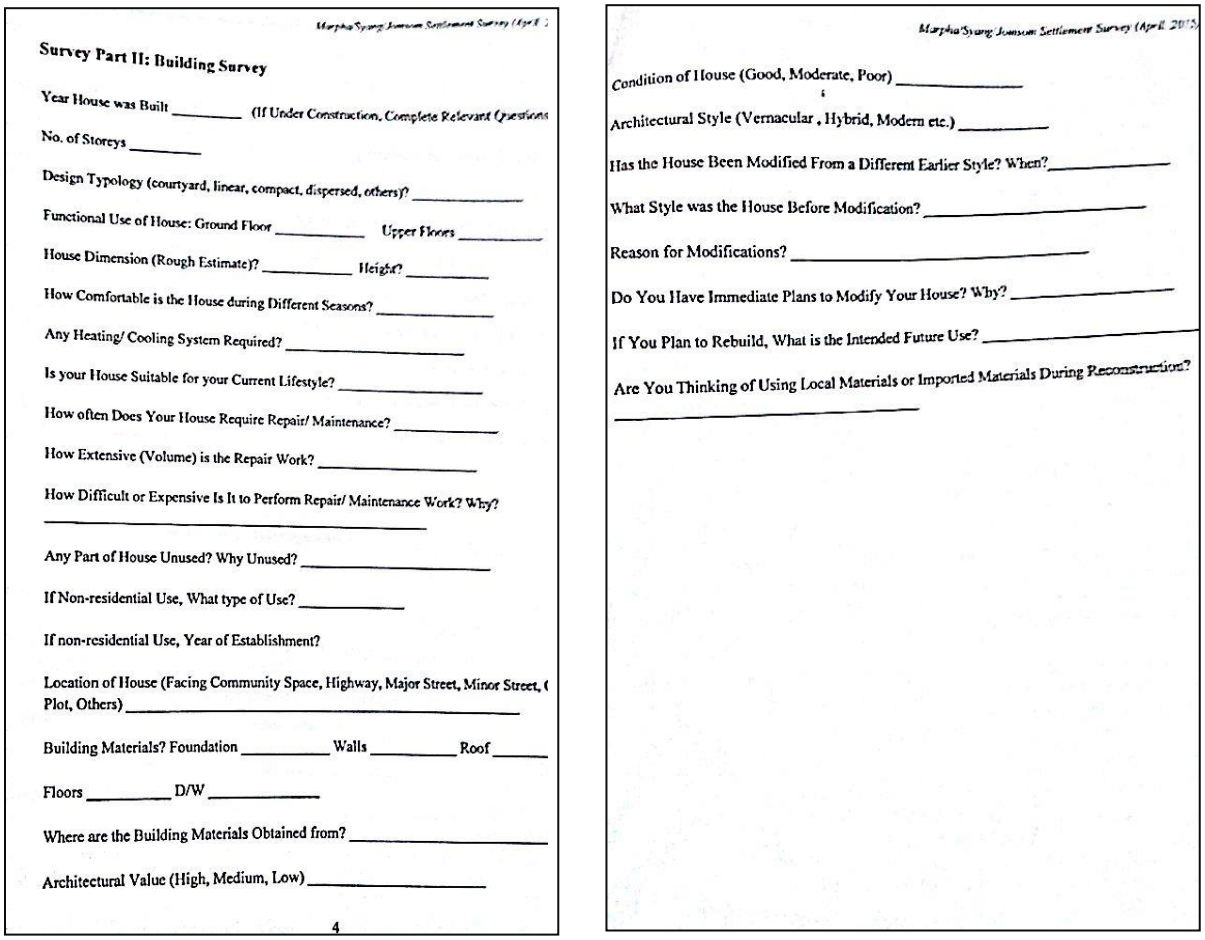
Sewage and solid waste disposal system in both villages are similar. Both villages have proper disposal system for both sewage and solid waste. Individual houses have well-facilitated toilets since the villages are marked as NO OPEN DEFECATION AND URINATION AREAS. The septic tank was reinforced, or pits dug nearby the toilets. The tanks were enough to hold the drainage for over a year and more. When a septic tank is

full, then it is pumped and disposed of in farmlands as fertilizers. The good thing about the villages is, they are aware of the cleanness of the river. The sewer is directly disposed of in agriculture land while the solid wastes are collected once a week and disposed of in a pit. The community group name Aama Samuha organize a program once a week to clean their village. All people mostly women participate in this program and clean their village. The collected waste is disposed of in a pit. The wastewater like water coming from bathing, cooking, cleaning, washing, etc. are disposed of in the drainage nearby. In Marpha, the community taps are placed in such a way that the collected water automatically falls into the drainage. The drainage takes wastewater to the river.

Chapter 4: Architecture of Marpha

Study of Architecture of Marpha

The architecture of Marpha, Mustang was surveyed and analyzed. The set of questions as shown in Figure 32, were prepared and the oldest part of the Marpha was studied. 257 buildings of the oldest part of Marpha were selected and the survey was conducted. The collected data was explained in this chapter. One of the oldest building was chosen and the detailed study about the building and people living in it was done. This chapter contains the detail description and analysis of the vernacular architecture of Marpha.



Survey Part II: Building Survey

Year House was Built _____ (If Under Construction, Complete Relevant Questions

No. of Storeys _____

Design Typology (courtyard, linear, compact, dispersed, others)? _____

Functional Use of House: Ground Floor _____ Upper Floors _____

House Dimension (Rough Estimate)? _____ Height? _____

How Comfortable is the House during Different Seasons? _____

Any Heating/ Cooling System Required? _____

Is your House Suitable for your Current Lifestyle? _____

How often Does Your House Require Repair/ Maintenance? _____

How Extensive (Volume) is the Repair Work? _____

How Difficult or Expensive Is It to Perform Repair/ Maintenance Work? Why?

_____

Any Part of House Unused? Why Unused? _____

If Non-residential Use, What type of Use? _____

If non-residential Use, Year of Establishment?

Location of House (Facing Community Space, Highway, Major Street, Minor Street, (
Plot, Others) _____

Building Materials? Foundation _____ Walls _____ Roof _____

Floors _____ D/W _____

Where are the Building Materials Obtained from? _____

Architectural Value (High, Medium, Low) _____

4

Condition of House (Good, Moderate, Poor) _____

Architectural Style (Vernacular , Hybrid, Modern etc.) _____

Has the House Been Modified From a Different Earlier Style? When? _____

What Style was the House Before Modification? _____

Reason for Modifications? _____

Do You Have Immediate Plans to Modify Your House? Why? _____

If You Plan to Rebuild, What is the Intended Future Use? _____

Are You Thinking of Using Local Materials or Imported Materials During Reconstruction?

_____

Figure 32: Questionaries' for the building Survey

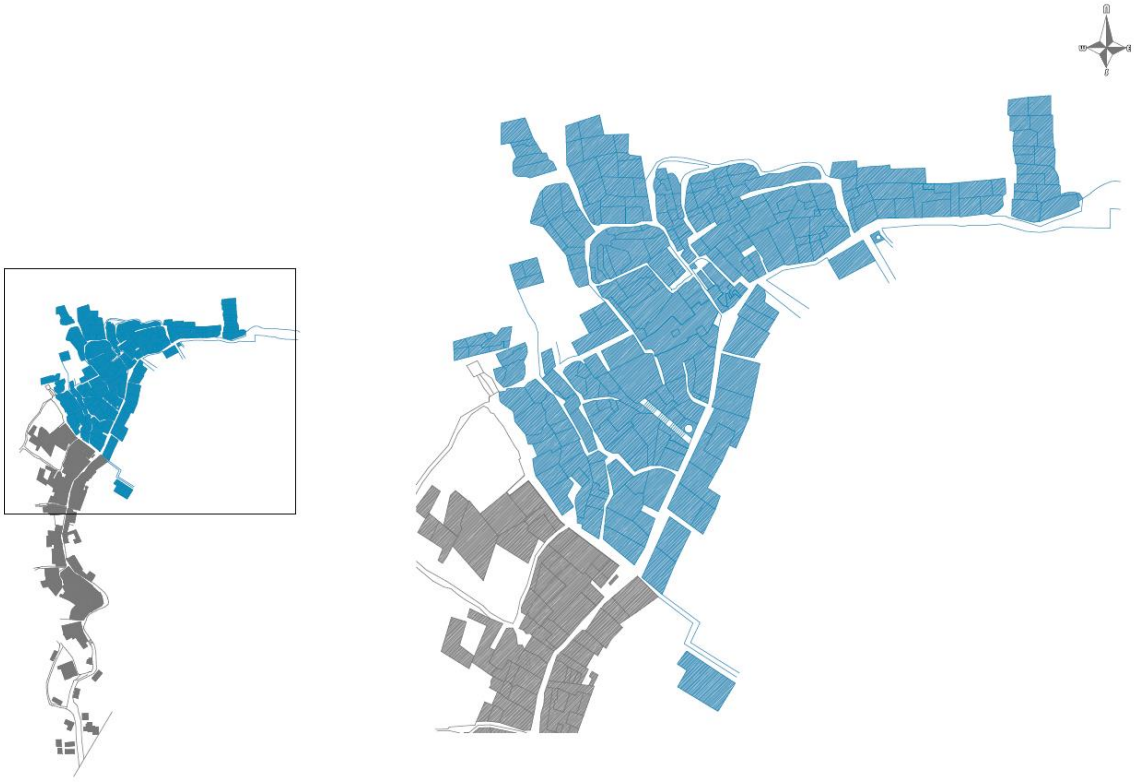


Figure 33: Map of Marpha showing the area of study

The architecture of Marpha can be overserved changing through time. The north-east part of the Marpha has the compact settlement with the stone buildings without courtyard. As we move towards the south, we can see that the architectural style is changed to compact stone building with courtyard. The contemporary architecture of Marpha, mostly build in the southern part, are single standing RCC structures.

Age of the Buildings

Marpha being oldest settlement have most of the vernacular buildings with age more than 100 years. The house has been legacy from more than 2-3 generations. 24% building is of average age built or re-built at recent times but most of them are still on the old foundation. 16% are less than 50 years. Only one is under construction. All the buildings on the north-east side of the Marpha are more than 200 years old.

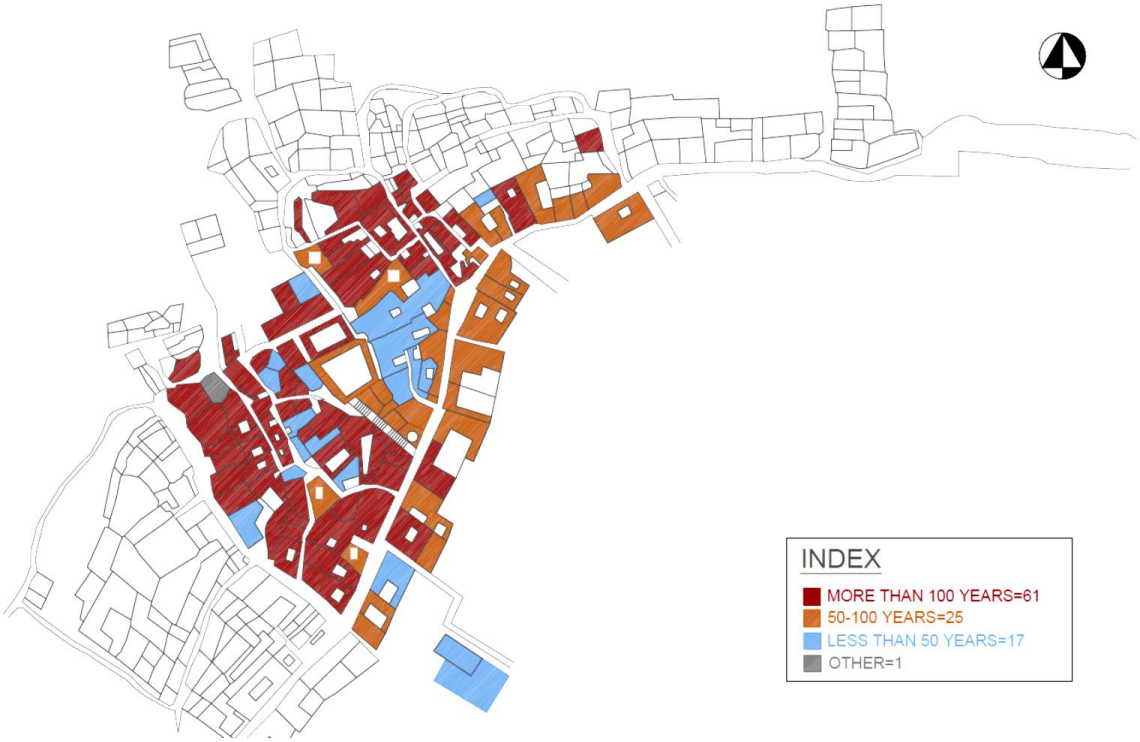


Figure 34: Map showing the age of the buildings

Use of Buildings

Among 257 buildings,168 were animal shades. i.e. 65%. 31% other are residences. 3% being public building and only 1% is a religious monastery. Among 168 animal shades, only around 20 were functioning. All others are abandoned and in very poor condition. These animal shades were reported as floor (oats) mill in the past. But with modern machines and installment of the factory, those mills are now turned into the animal shade (goth).

The buildings in the north-east part of Marpha are the oldest one which is currently used as the animal sheds. As per the local villagers, the settlement was moved from the northern part to southern part due to the threat of landslide.

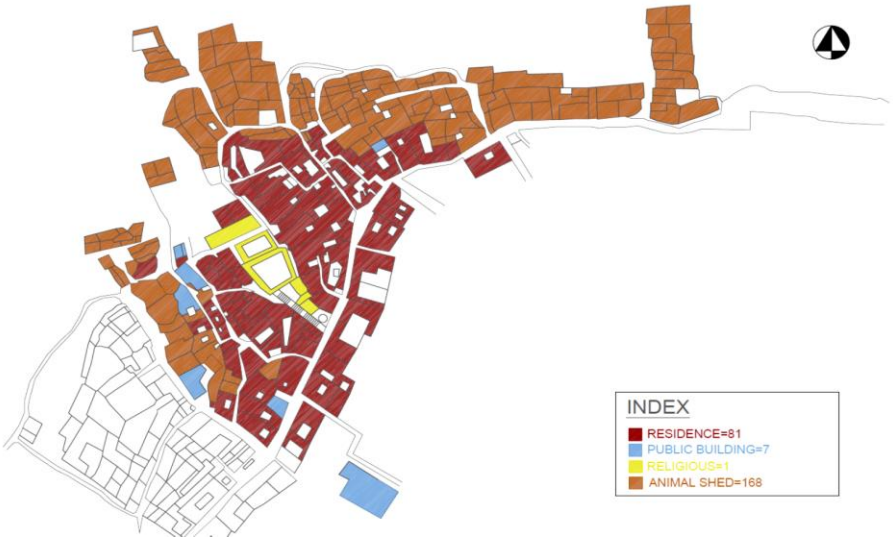


Figure 35: Map showing use of the buildings

Design Typology

The design typology of Marpha is diverse. 43% of the buildings have an open courtyard, 24% of the building has covered courtyard with corrugated GI sheets. Few have used a transparent sheet for light. 23% of the building is compact and only 10% are linear.

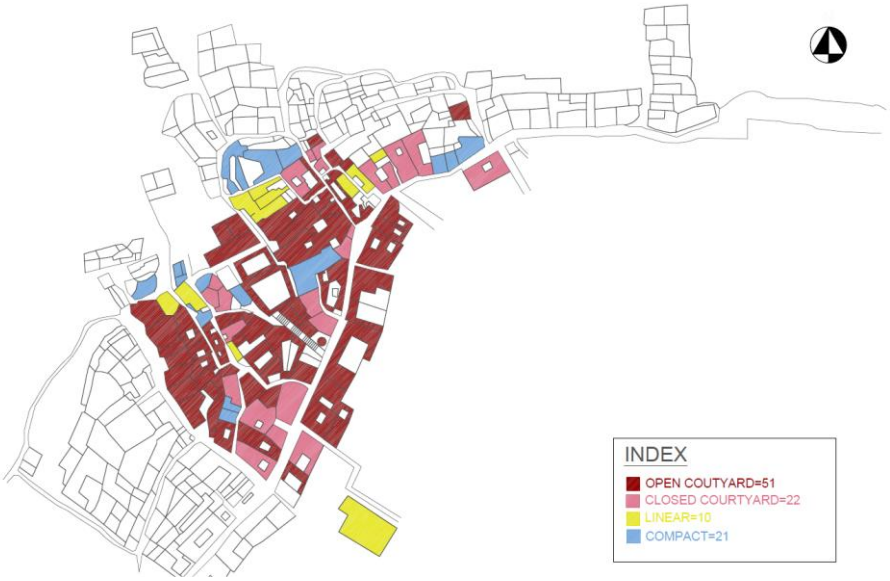


Figure 36: Showing Design Typology

Architectural Style:

Almost all the building in old Marpha (an area we surveyed) are vernacular architecture i.e. 97%. Few 2% building are hybrid due to re-construction. During re-construction, building façade has been continued as in the vernacular. Floor heights, structure and functional aspects are as per modern need. 1% of modern building is totally contemporary architecture also being true to its material.

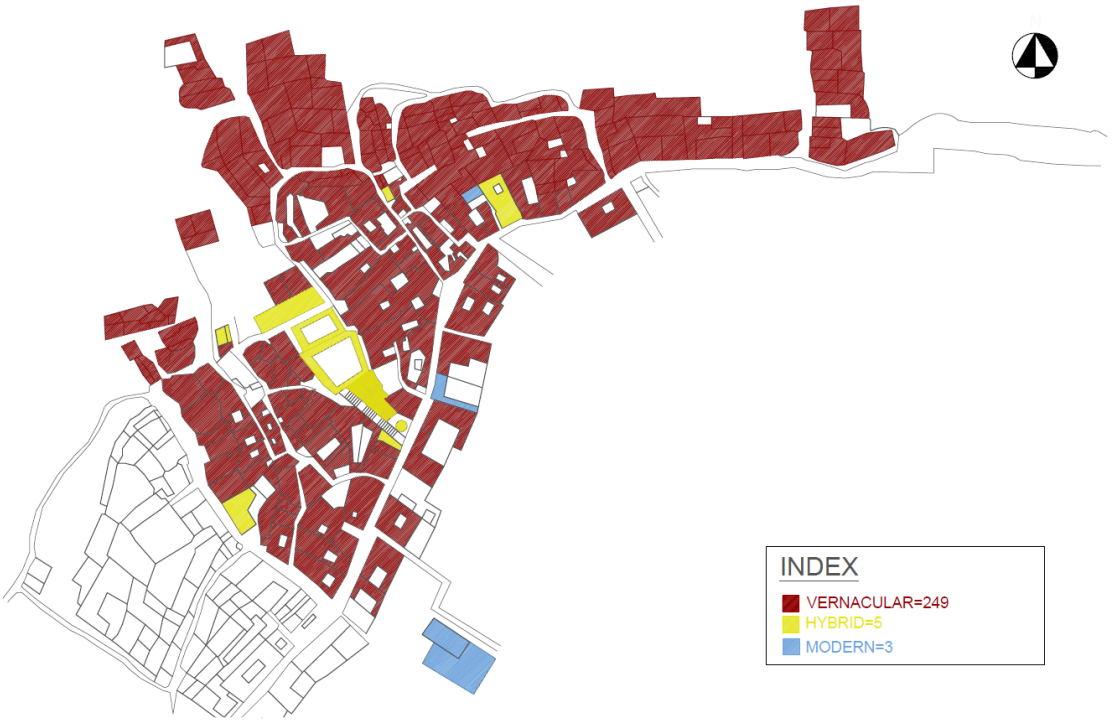


Figure 37: Showing Architectural Style

WHOLE MARPHA

The Architecture style and age of building of the building were studied for the whole Marpha. Most of the buildings were found to be of vernacular architectural style. Those buildings were the oldest one. The oldest architecture was more than 200-300 years old, but those buildings were not used as residential building anymore. The purpose of those buildings has been changed to animal sheds. The comparison of the collected data shows that the oldest buildings are more vernacular while the buildings 50-100 years are more hybrid and the buildings less than 50 years are more modern.

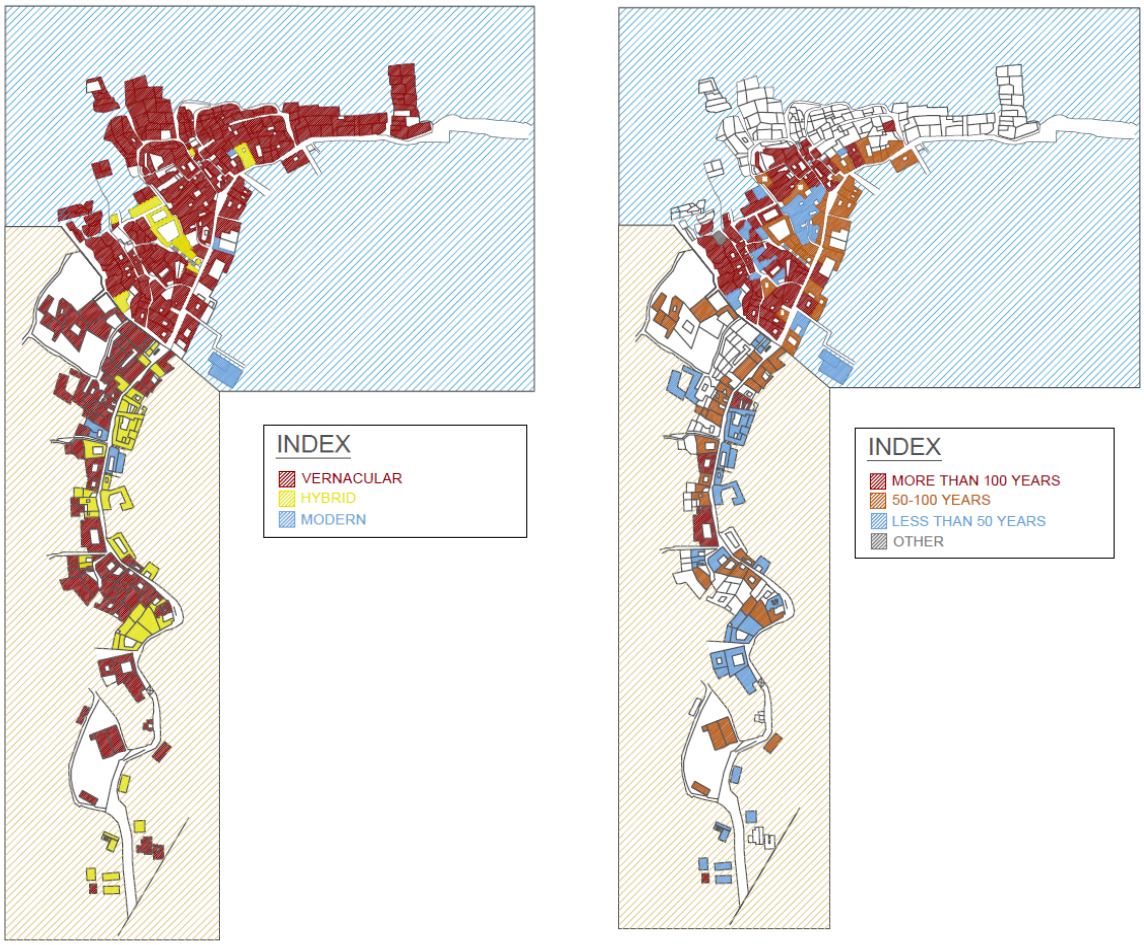


Figure 38: Showing architecture style and age of building for whole Marpha

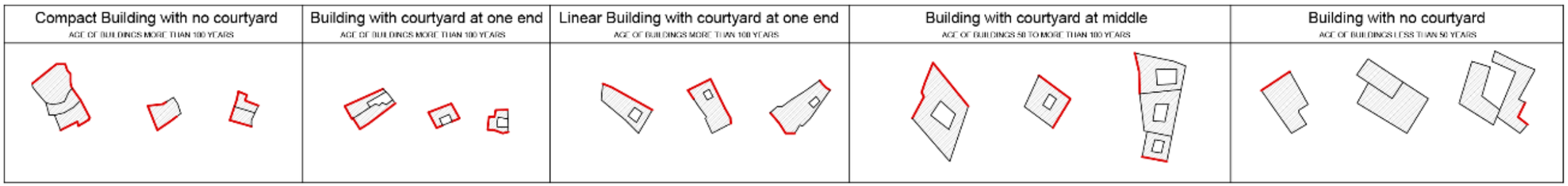


Figure 39: Building Typologies, age of building and different orientations

Building Typology

From Figure 39, we can see the change in the architectural form along with the time. Three significant changes can be concluded, 1. Size of building 2. Composition of building 3. Architectural style.

The size of the building can be seen increasing which is assumed due to the change in the culture of the community. People are considering their privacy more important nowadays than before. This change is also the result of a change in the economic condition. Due to the development of road and airport people have more exposure and more opportunity which help to increase the economy of the people and hence the economy of the community.

The red line of Figure 39 is the side of the building that is attached to another building. From left to right, with time, we can see how the buildings used to be more compact and attached to other buildings before and now buildings are more standing alone or attached at only one side.

The architectural style can be seen changed from the compact to courtyard style to more linear buildings. Assuming that, with the development in construction the courtyard was introduced in the building. Since, there used to be less or no rainfall before, the courtyard would provide space for the light and solar radiation. The courtyard creates nice microclimates in each building allowing more sun and light.

But with the change in the rainfall pattern, now the vernacular architecture with mud mortar and improper drainage system are creating a problem. So, people are changing their courtyards into the atrium and in new construction, people do not prefer courtyard at all.

Vernacular Architecture

Figure 40: 3D model of vernacular architecture studied

One of the oldest vernacular architecture was taken as a case study and the detailed study was done. The building is located at the center of the Marpha. It was built more than 100 years ago. The exact age of the building is unknown to the owner. The owner name is Dev Bahadur Bika. Four people lived in the building: husband, wife, father, and mother. Dev works ass as the metal utensil maker. The family is an occupational group and considered as the lowest class family in society. They migrated from Butwal because of the hot weather. All family members work for a living. While Dev has his metal making business at home, he along with other family members are involved in agriculture. They are Hindu by religion and speaks Nepali as their mother tongue. Their home is the family home is passed along generation to generation. Since, neither dev nor his father knows who built the house the age of the building is unknown and for this research purpose, considering the fact that building is certainly more than 100 years old I am considering the age of buildings is more than 100 years ago.

Table 2: General Information of the house

Location	Age of building[a]	Building Stories	Architectural Style	Building Typology	Orientation	Function	Occupancy
Marpha, Nepal	>100 years	One and half	Vernacular Architecture	Rectangular Plan with Courtyard	32° to the west from North	Living and Working Spaces	Four

[a] exact age of building unknown

BUILDING LAYOUT

The building is vertically divided as per the use of the buildings. The upper floor is used for private purposes: cooking, sleeping and living while the ground floor is used for more public purposes: working, animal shed, storage. According to the villagers, they prefer to live in the upper floor because it prevents the direct coldness from the ground and they also believe that the heat loss by the animals below helps to keep the upper floor warm.

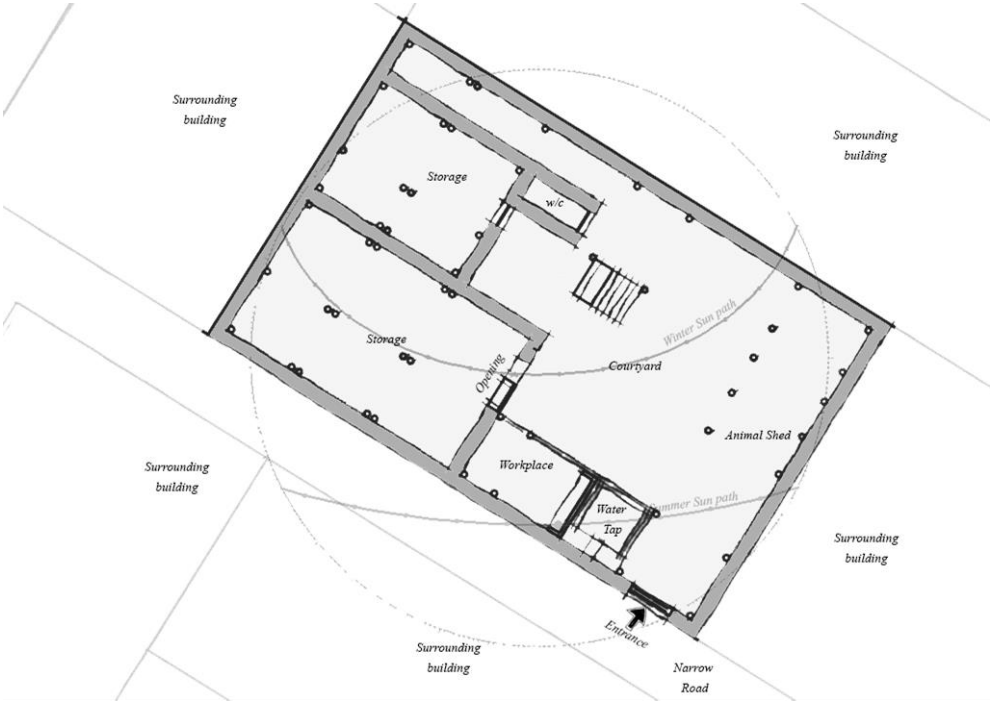


Figure 41: Ground Floor plan

Figure 42: First Floor plan

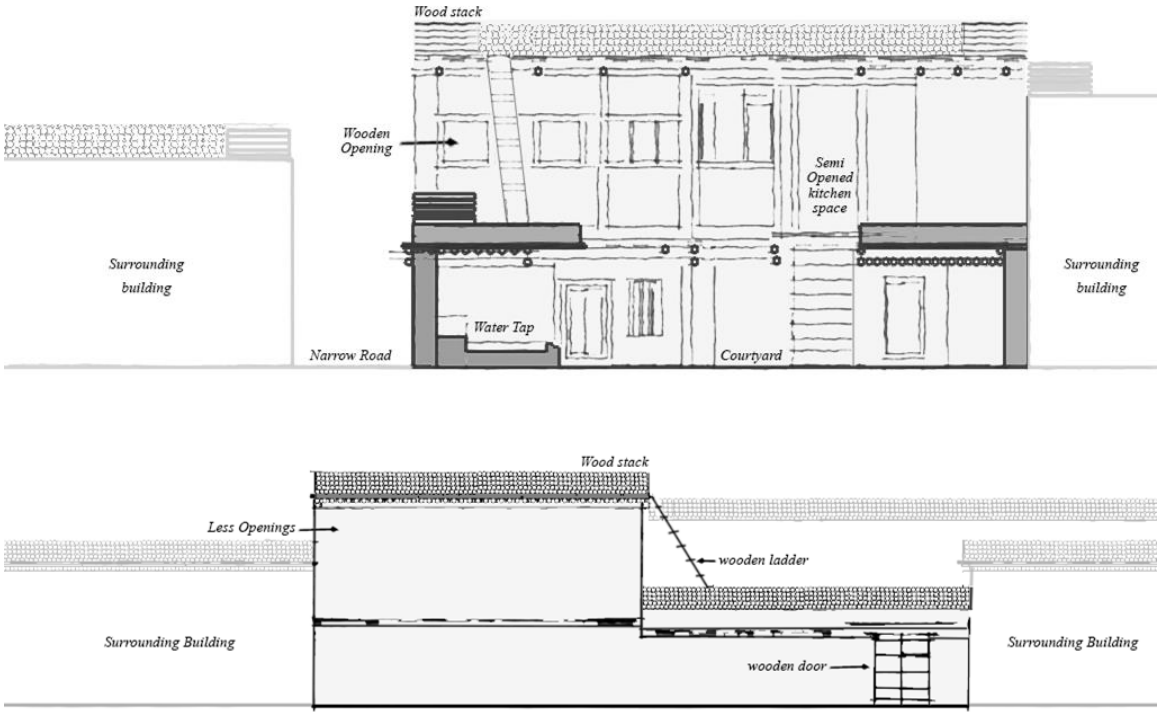


Figure 43: Section and Elevation of the building with description

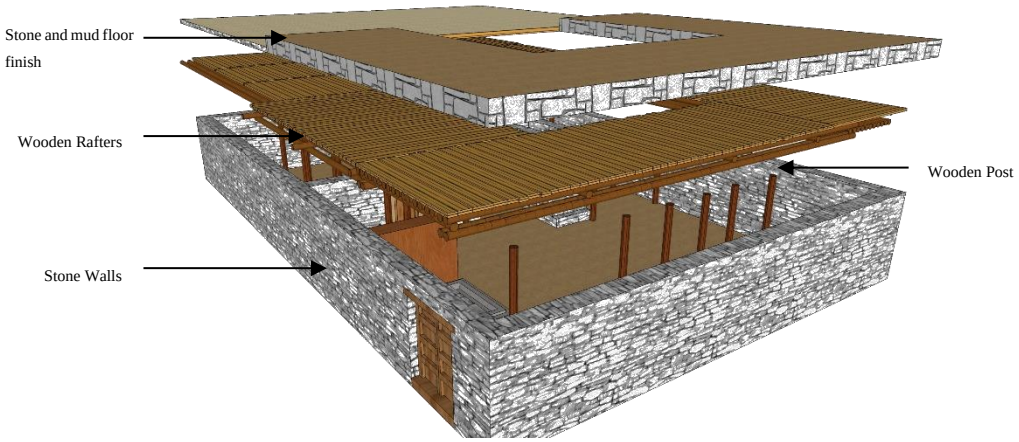


Figure 44: Structural detail of the vernacular architecture

The wall thickness of building is 14" which reduce the heat exchange between the surfaces and insulate building thermally. Structurally, the ground floor has 4" wooden pillar with three layers of wooden raters. Over a wooden beam, the wooden plank is placed with stone and mud floor finishing. The depth of the slab is deeper in balcony space than in other parts.[31]

BUILDING ELEMENTS

Foundation:

The foundations and plinth are of stone rubble masonry using mud mortar. The foundation depth is a maximum of 60 cm (24") The rubble masonry is often raised up above the ground floor level. Foundation runs above the earth to form the wall and it has a

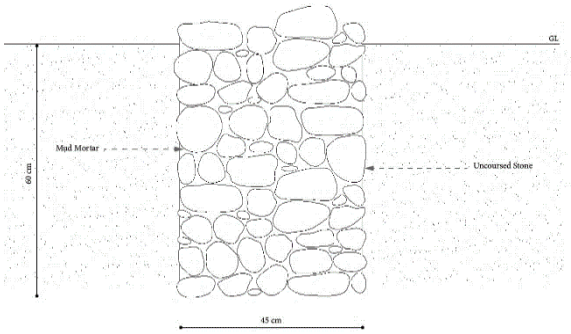


Figure 45: Foundation detail

[31] *Asmita, D. et al. (2014) Marpha Settlement Study. Settlement Planning Course Report. Nepal Engineering College*

similar thickness to that of wall i.e. at least 45 cm (18”). [32]

Wall:

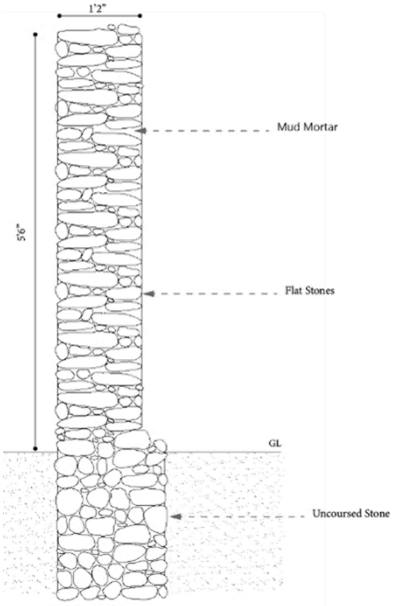


Figure 46: Wall Section of stone

Generally, in Mustang, the main construction materials of the wall are stone and earth. The earth walls that are 45 cm thick are constructed either rubble masonry or rammed earth (gyanka tha). Earth construction is preferred wherever the soil quality allowed. Rubble stone masonry is preferred if the soil quality is not suitable.

Construction of the rammed earth wall is a step by step process. At a time, the wooden shutter of fixed length and height (about 18 inches) are positioned on top of the foundation and mixture of earth, grain stalks and husk are rammed by the wooden handle and is left to dry for a couple of days before construction of a wall on top of it.[33]

In the case study building locally available flat stones are used with the mud mortar. The height of the stone wall is 5’6” on the ground floor while on the upper floor it is 7’6”.

Roof and floor:

Most of the roof in mustang is flat. The flat roofs give the freedom to construct irregular shaped rooms and add the extension. Each room is enclosed with earth walls, the roof or next floor being supported by central wooden posts. Wooden brackets on the posts give better support to the main beam, which is supported on the ends by additional posts

[32] *Raj Kumar, K. et al. (2014) Jomsom Settlement Study. Settlement Planning Course Report. Nepal Engineering College.*

[33] *Raj Kumar, K. et al. (2014) Jomsom Settlement Study. Settlement Planning Course Report. Nepal Engineering College.*

or stone wall-plates. The joists are usually round sections of 4" diameter, placed 18" apart. The joists are covered with planks or split wood, a layer of wheat stalks and twigs covered with approximately 4" of packed white clay (Sakara mud). The side walls are raised slightly above the level of the roof to clamp down the beams and joists.[34]

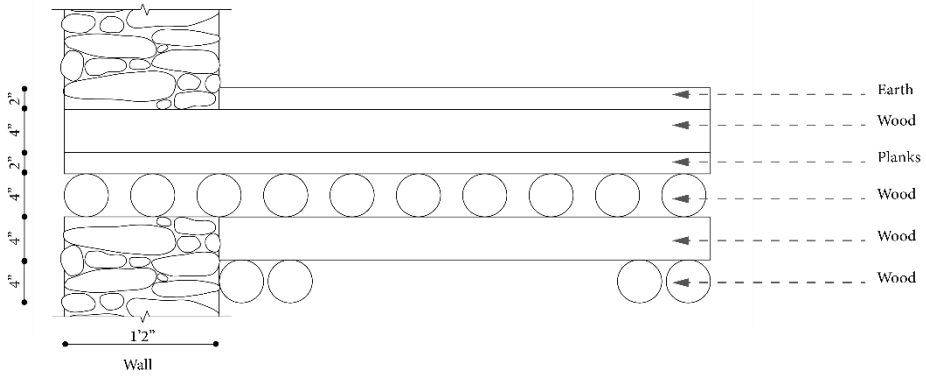


Figure 47:Floor detail inside room

In the case study building, there are two different types of roof, one with the stone and mud finishing at the balcony spaces whereas another one with the wood and earth finishing at the top. The floor of the rooms also has wood and earth finishing.

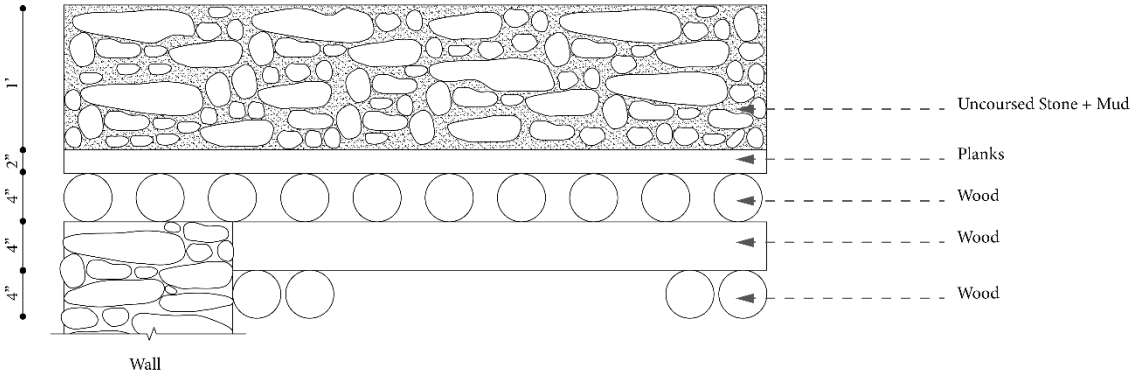


Figure 48: Roof detail with stone and mud finishing at Balcony

[34] *Raj Kumar, K. et al. (2014) Jomsom Settlement Study. Settlement Planning Course Report. Nepal Engineering College.*

Figure 49:Roof detail with earth, wood and planks finishing at top

The roof of the Mustang is one of the unique roofs in the world. The tradition of Mustang is to stack wood the through generation to generation at the top of the building around the roof. It helps to separate the compact houses from each other. We asked people over there and we got many reasons behind it. One of the reasons was that every people stack the wood on their roof so that it could be used at the time of their death for burning. Some people said that it shows how wealthy the family is, according to the more the logs are wealthier the family is considered. Another reason we heard is the log in each house were kept by their ancestors and it as a blessing for them. Since there is lack of trees in mustang, people said that they stack the woods through generation to save wood as much as they can and so that during winter, they can use those wood for heat.

Figure 50: Wooden stack on roof

Openings:

The openings on the external walls are usually small whereas the larger ones are opened on to the courtyard. In some cases, a double frame is used to support the thick rammed earth walls. Wooden blocks that span the width of the wall are fixed perpendicular to the top member of the frame, which is then covered with wooden planks to hold the earthen wall. Double leaf wooden shutters are positioned on to the frame and are opened inward to the room. Marpha is much more influenced by Tibetan traders and have Tibetan design on windows and doors. The wood used is most often Pine, though in the older buildings the main structural elements were constructed of Juniper. Openings on top of the roofs are also seen for skylight and smoke outlet purpose.

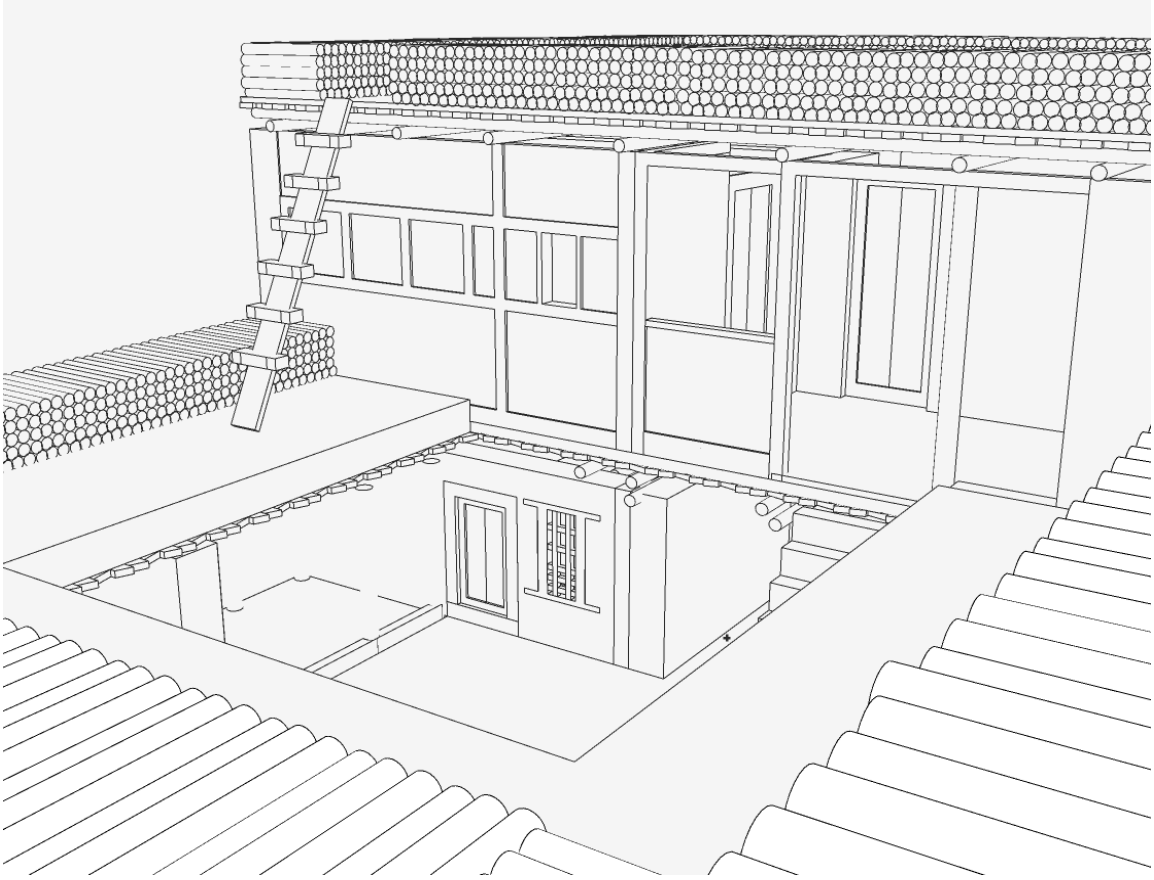


Figure 51: 3D mode of case study building showing openings

In the case study building, there are two different types of openings, one big wooden opening facing the courtyard on the first floor and another small one on the ground floor also facing the courtyard. There is no opening on other walls of the buildings which increase the importance of the courtyard as it is the only source of the light and heat.

Plaster and painting:

In mustang, plasterwork is not common for rammed earth wall or neither for stoned wall buildings. But mud and lime plaster works are seen in few buildings depending upon the owner's choice. However, painting of the houses is must and the houses are whitewashed by lime. Doors and windows are painted red by enamel or by mukpa (reddish-brown color- locally available material). The case study buildings are also whitewashed by lime and the door and windows are painted by red enamel.

Figure 52: Pictures of the case study building

Table 3: Investigation of building elements of vernacular architecture

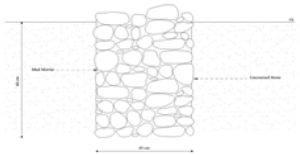
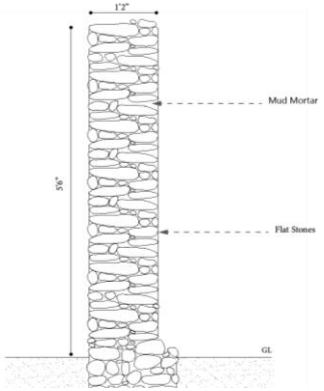
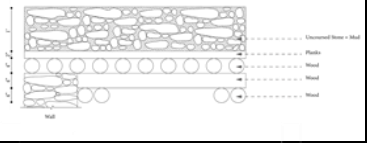
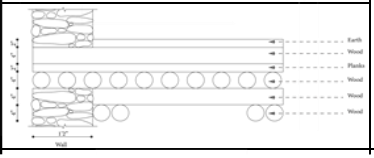
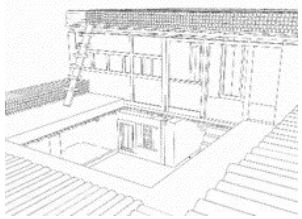
	Drawing	Material		Size	Construction
Foundation		Stone Mud		60 cm deep 45 cm thick	Stone rubble Masonary with Mud Mortar
Wall		Stone Mud	Earth	1'2" thick 5'6" tall	Rammed earth Structure known as gyanka tha (interior walls) or Stone wall with mud mortar white washed with lime
Roof		Wood Earth (sakara) Plank	Wood Earth (sakara) Stone Plank	1' thick	Wooden post with wooden brackets with wooden beam structure supporting planks and earth, (earth with stone at balcony)
				2'2" thick	
Floor				1'4" thick	

Table 3, cont.

Structure		Wood Earth Plank	5'6" long post 4" round wooden post and beam 2" plank 2" earth (at room) 1' stone and earth (Balcony)	External load bearing stone walls with internal earth rammed wall along with stone post supporting the wooden beam, wooden joist and earth floor.
Openings		Pine and Juniper Wood	small windows 2'x1' Big window 2'8"x1'	Wooden Frame with the no shutter or inward opening double leaf wooden shutter
Plaster and Pinting		Mud Lime Mukpa (reddish brown color- locally available material)	-	Wall: Mud and lime plaster works and painting with white washed by lime. Doors and windows: Painted red by enamel or by mukpa

MATERIALS

The material used in the vernacular architecture is the stone, earth, wood, limestone, and red mud. All of these materials are locally available. The stones are collected from the banks of Kaligandaki and Thak khola. Larger sized stones are found on the mountain quarries and they are hammered into desirable size for construction.[35] The bare mountains are the sources of the clay for the rammed earth construction with limestone and red mud for the wall painting. The wood used in the vernacular architecture is also available locally in the nearby forest.

We can see that all the material used in the vernacular architecture are locally available. The closed-loop system can be seen, where the material from nature eventually ends up in nature. Since all the materials are locally available, reducing the transportation cost and energy.

Table 4: Description of materials used in vernacular architecture

Material's Name	Availability	Note
Stone	Riverbanks and mountain quarries	Locally Available
Wood	Forests controlled by ACAP	Locally Available
Earth	Surrounding open areas and mountains	Locally Available
Limestone and paints	Surrounding mountains	Locally Available

[35] *Raj Kumar, K. et al. (2014) Jomsom Settlement Study. Settlement Planning Course Report. Nepal Engineering College.*

Chapter 5: Analysis

Architecture and Sustainability Analysis in Vernacular Architecture

BUILDING ORIENTATION AND SOLAR STUDY

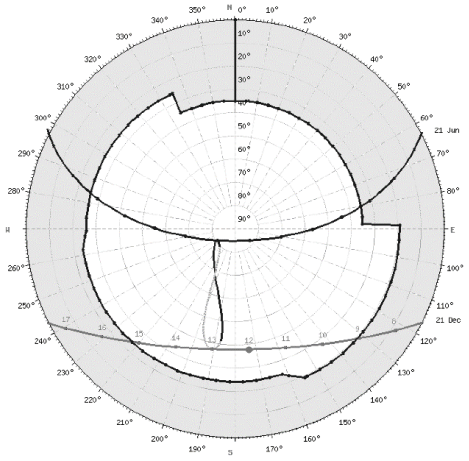


Figure 53: Shadow mask for December

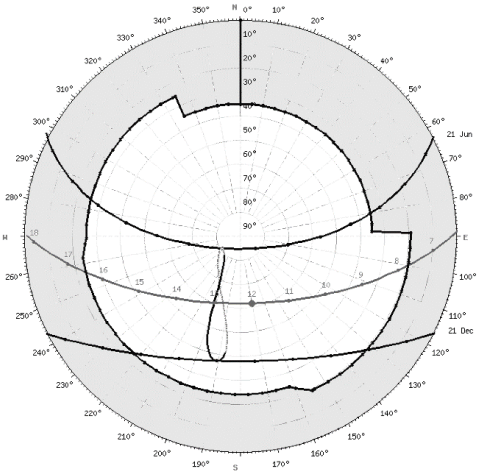


Figure 54: Shadow mask for September

The case study building is oriented 32 degrees to the west. Since the building is in the compact settlement, the solar analysis is done to understand the heat gain in the building as shown in following figures.

The shadow masks are prepared at the courtyard on the ground floor. Since all the openings are facing the courtyard and the courtyard is one of the main sources of heat and light the solar study is done at the courtyard.

As we can see in **Error! Reference s ource not found.** the building is exposed to solar radiation from 9:00am to 3:00pm. The morning the evening solar radiation is completely shaded by the surrounding buildings in winter. While for September, as shown in Figure 54 the building has solar exposure from 7:45 am to 4:30 pm. For summer, the building is exposed to sun form 8:30 am to 5:15 pm as shown in Figure 55.

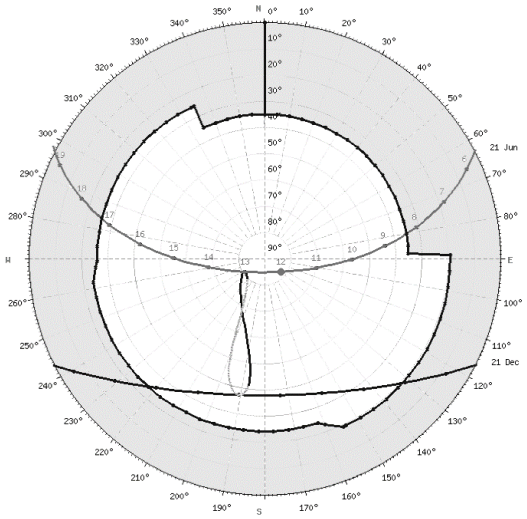


Figure 55: Shadow mask for June

The room facing the courtyard has the maximum solar heat gain while the rooms at south lack the opening and have low solar heat gain which is not an ideal design strategy for the weather like Marpha. Even though there is no direct heat gain through the openings, the stone wall with high thermal mass gains heat and store them during the day and release at night.

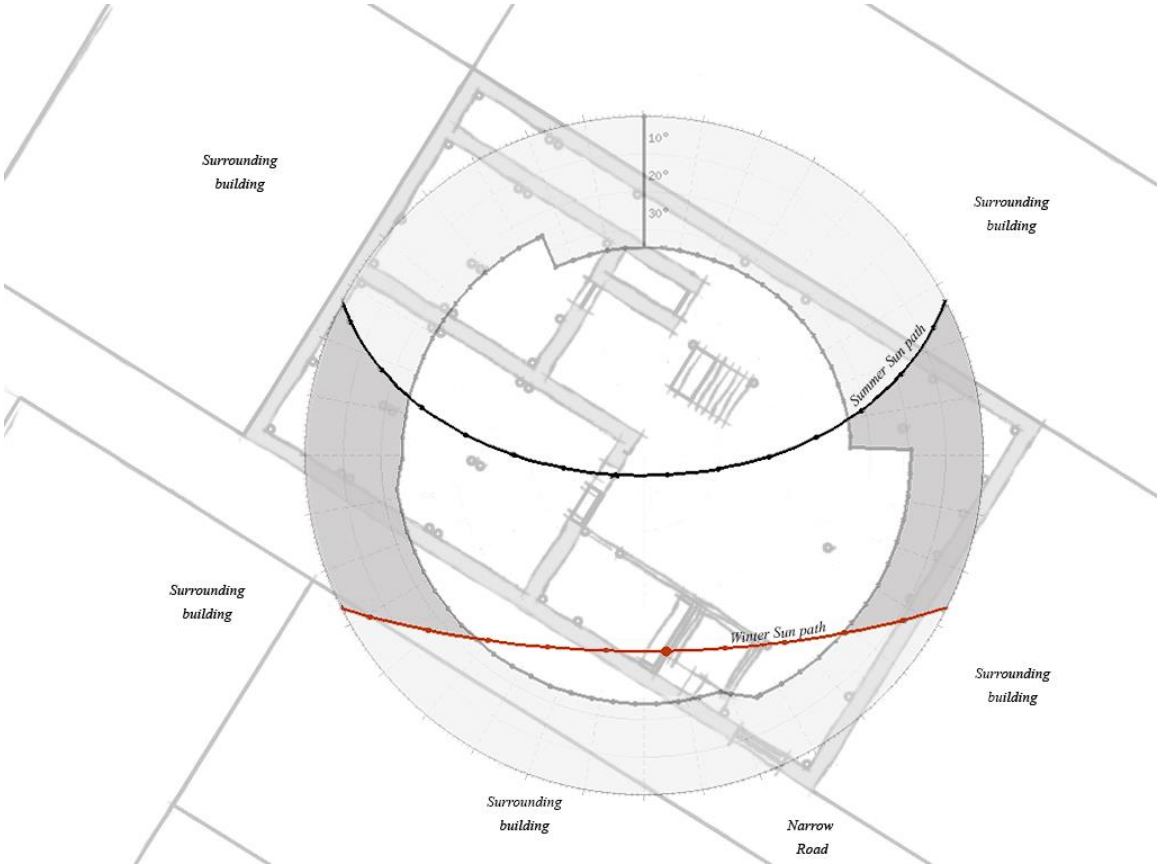


Figure 56: Shadow Mask of the case study building at first floor

As shown in Figure 56, in the case study building the light and heat are gain is through the opening facing courtyard. Due to the clustered settlement, the wind is avoided inside the building. The attached wall prevents the heat loss to the surrounding which helps to maintain indoor climate warm.

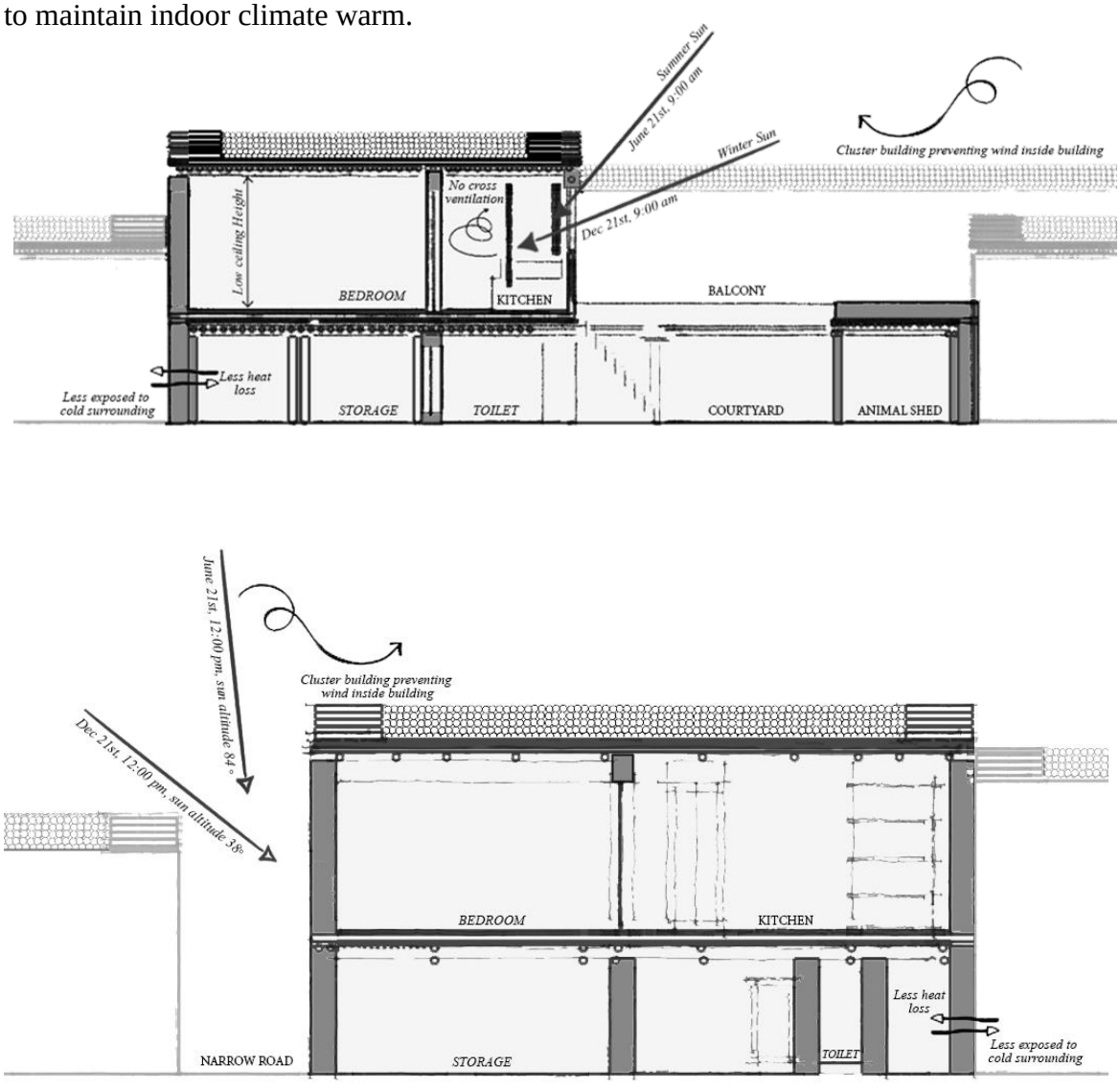


Figure 57: Section of building showing the max and min sun angle

As shown in Figure 57, the maximum summer sun angle is 84◦ which gives us an idea that the shading in this area is not needed during the summer. The minimum winter

angle is 38◦ which means with the proper opening, the sun will be able to penetrate deep inside the room.

In the case study building as shown in Figure 57, the sun is welcomed in winter through the openings in towards the courtyard. Due to the lack of opening on other walls, the direct heat gain is not possible but since the stone has high thermal mass, it absorbs the heat whole day and releases them during the night. No shading devices are provided on the building because the angle of the sun is high during summer.

Heat exchange with the environment is encouraged with the increase in the surface area. More the walls are exposed to the environment, more will be the heat loss. The compactness of the settlement decreases the surface area exposure reducing the heat loss from the building which is one of the important design strategies that we can see in the vernacular architecture.

The low ceiling height of the room also helps to reduce the airflow. Since the hot air rises, lower the ceiling height closer to the warm air.

Along with the cold, the wind is another main problem in this area. The buildings are attached to each other which helps to decrease the air infiltration inside the buildings. The lack of windows in either wall, reduce the cross circulation of the air, decreasing the wind penetration inside the buildings.

DAYLIGHT

The daylight for the case study building is studied with the use of the software SketchUp and plugin DeLuminae. As shown in Figure 58, the rooms at the back lack proper daylight. Daylight is one the important factor for the building, but it can be seen, in the vernacular architecture of Marpha, it was not properly designed or taken as important as it should have been. Even though small windows in less number favor to avoid the wind it is not favorable for the daylighting.

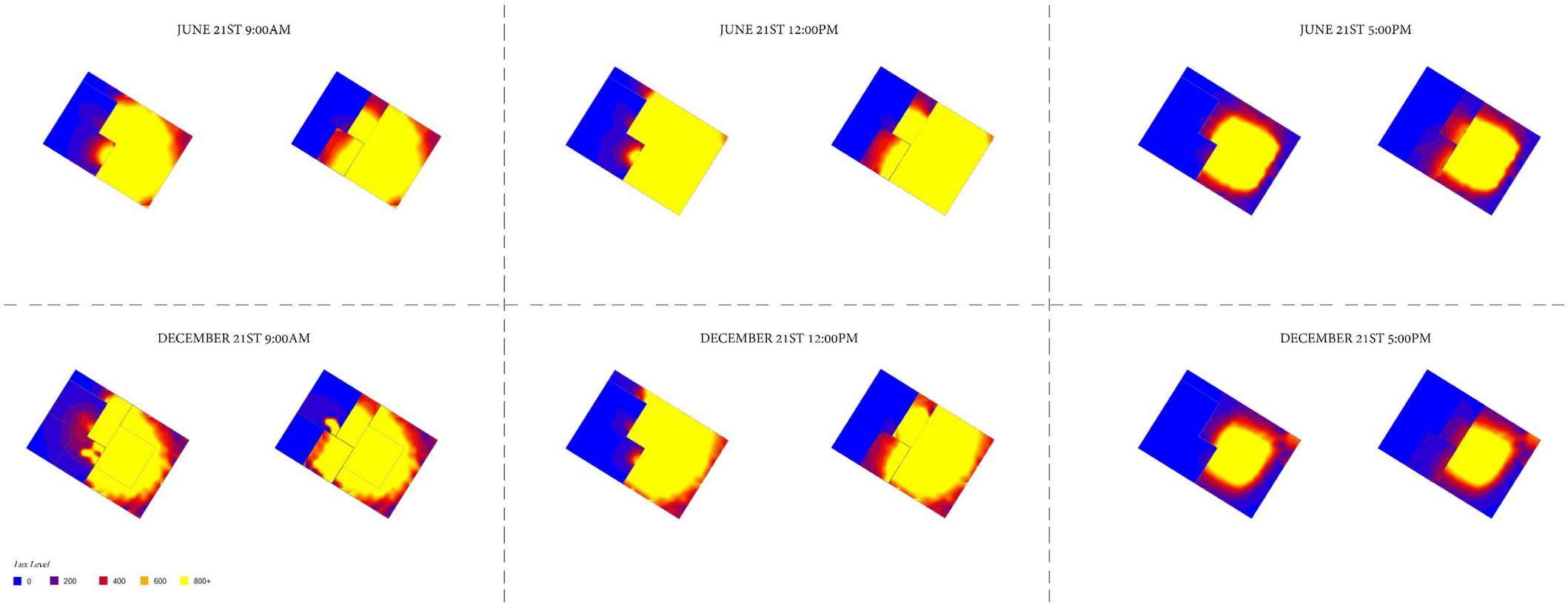


Figure 58: Daylight Autonomy

ENERGY

The vernacular architectures of Mustang are free running. There is no use of energy for heating or cooling purpose. Electricity is the only use of energy. At the beginning of the research, I did the energy analysis of the free-running case study building using Open studio and Energy Plus. Then the same building was analyzed with the use of external heating energy source to understand the change of energy use and comfort of the people. After my research and understanding about the village, it came to the knowledge that the energy supplied to the buildings are produced through hydropower which is the renewable source of the energy. Even though the building energy use increased, and the comfort level changed, as long as the energy is supplied through the renewable source, the impact towards the climate is lessened. The only non-renewable energy used is in the transportation of energy. But as per my study, the electricity is produced from the closest river.

Even though the energy supplied through the renewable source, there can be a negative impact on the excessive use of energy. For example: if houses start to consume a double amount of energy then the source needs to produce more. The increase in the production of energy causes the use of more nonrenewable energy during production and transportation. Even though there might be less direct climate impact of the more energy in the place like this, there might be severe indirect impact, which can be the topic for another research.

For this research purpose, since the energy is supplied from the renewable source, assuming that it has a less climate impact, only the level of comfort is studied. We can confidently conclude from our study that; the external heating source is required for this place. I ran the simulation and compared the level of comfort with the thermal comfort zone concluded from research for the people living in Marpha.

Baseline Envelope and Loads:

The simple model was constructed in the open studio, using own space for each room. Assuming that, the surrounding buildings plays an important role in the energy simulation all the existing attached buildings are modeled as shading.

Different construction sets, thermal zones, schedules and internal loads are assigned to the model. Since the most functioning spaces are living room, bedroom and kitchens this project is more focused on the energy simulation of those spaces.

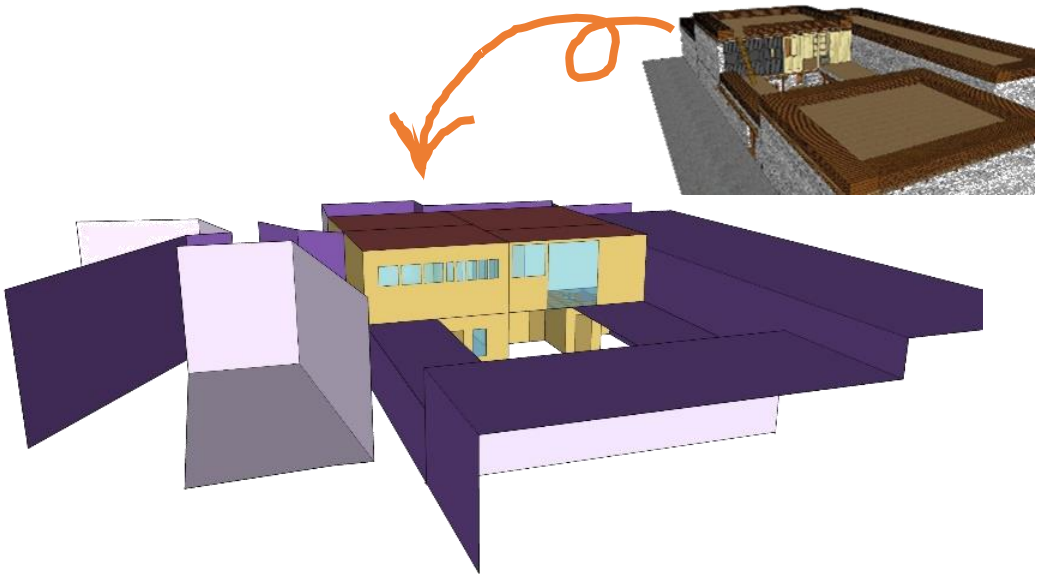


Figure 59: Model of the building in open studio

Construction Material:

The model was prepared with stone as the main construction material. The upper floor was modeled with stone and wood. One the limitation of using open studio was that I was unable to create the semi-covered space, so I created the window with high visual transmittance for the semi-covered space and scheduled the space accordingly.

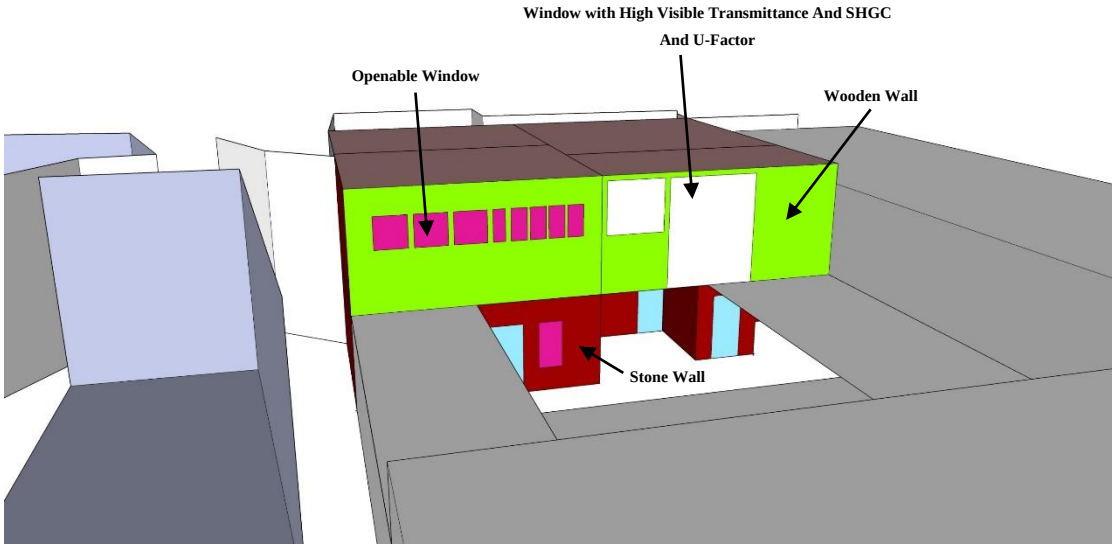


Figure 60: Model showing Construction Material

Thermal Zones:

Three different thermal zones were assigned to these spaces as the kitchen is semi-covered and has a furnace in it, the bedroom has openings whereas the living room does not. Rest of the spaces are assigned as another thermal zone.

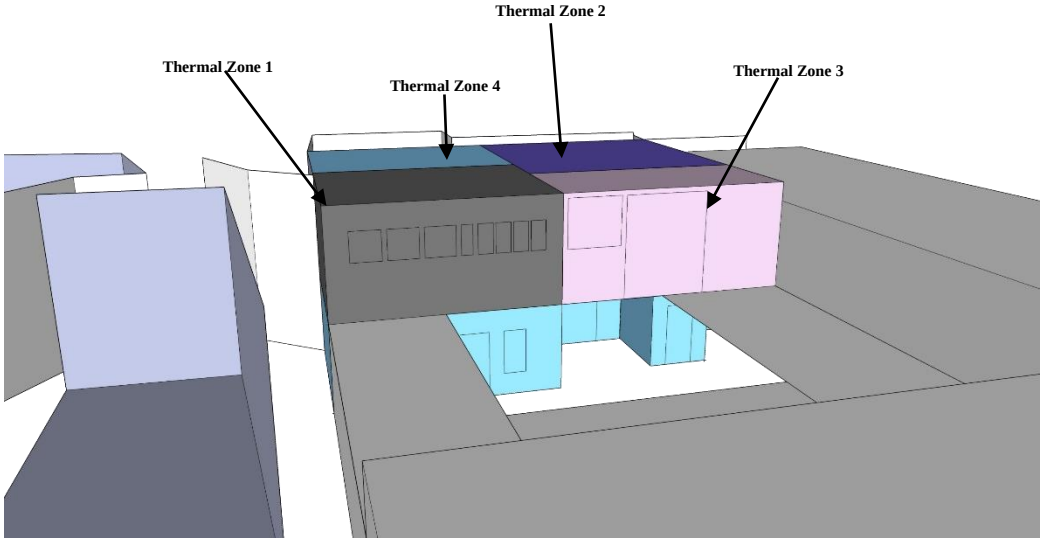


Figure 61: Model showing thermal zones

Schedule, Loads and Analysis:

The four people in total, 60-watt electric lighting in each room and plug loads of 1.67 w/ft^2 in the bedroom, 1.14 w/ft^2 in the living room and 2.18 w/ft^2 in the kitchen were added as an internal load for the simulation. Following schedule were added for the internal load, fenestration and the activities.

Table 5: Schedule for the simulation

Schedule	Number	Location	Time
People	1	Living Room	9:00PM-5:00AM
	4		8:00AM-12:00PM 3:00-5:00PM
	1	Kitchen	5:00-6:00AM 5:00-6:00PM
	4		12:00-3:00PM 7:00-8:00PM
	2	Bedroom	9:00PM-5:00AM
Activities	120 watt per person		
Fenestration	Summer		5:00AM-9:00PM
	Winter		-
Lighting	60-watt electric lighting in each room		
Plug Load	As per occupancy and the daylight		

Simulation and Results:

Table 6: Indoor Temperature and hours per year for free running building

Zone	Unmet Htg (hr)	Unmet Htg - Occ (hr)	< 56 (F)	56-61 (F)	61-66 (F)	66-68 (F)	68-70 (F)	70-72 (F)	72-74 (F)	74-76 (F)	76-78 (F)	78-83 (F)	83-88 (F)	>= 88 (F)	Unmet Clg (hr)	Unmet Clg - Occ (hr)	Mean Temp (F)
THERMAL ZONE 1	0	0	1711	1321	2571	512	420	412	326	262	235	476	325	189	0	0	64.7 (F)
THERMAL ZONE 2	0	0	1313	729	2503	574	520	482	488	403	347	752	504	145	0	0	67.3 (F)
THERMAL ZONE 3	0	0	2433	2167	3011	562	345	176	61	5	0	0	0	0	0	0	60.3 (F)
THERMAL ZONE 4	0	0	1710	863	2619	549	467	421	391	302	284	584	357	213	0	0	65.7 (F)

After the simulation, the indoor climate was studied. For the free-running building, the indoor temperature was between 56-68◦F (13-20◦C). According to the literature, the thermal comfort zone for the developing countries is between 18-29◦C, but according to our survey, since most of the people responded they feel comfortable in the building, for

this research the thermal comfort zone for Marpha is assumed to be between 16-30◦C. According to the simulation, the building still needed to be heating for about 4600 hours per year.

MATERIAL AND RESOURCES

The sustainability of the building is highly depended upon what type of material we use, where that material comes from, how it has been transported to our site, how it has been used and how it is going to be disposed of after its life ends.

As already mentioned in Section 2.2.3 Materials, most of the material used in the vernacular architecture is locally available. Since the materials are available in and around the site, the transportation cost and energy are saved. The material does not require further any kind of support for its operation. Since the buildings more than 100 years old are still standing surviving 2-3 major earthquakes we can say that the life span of the material is more than 100 years old. The material is from nature and it goes to nature after the end of its life, there is no energy used or any unnecessary pollutants created harming nature.

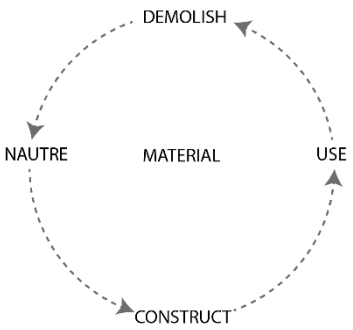


Figure 62: Close Loop System

Major building materials are stone and wood, and both can be reused and recycled. Both materials are environmentally, socially and economically preferable. The cradle to cradle approach can be used in these materials as they create the closed-loop system as shown in Figure 62. In vernacular architecture, we can see the materials are sustainable building materials and they reduce and divert the waste from the landfills.

Parametric Analysis

There are so many things we can learn from the vernacular architecture of any place. The sustainable architecture might seem like new and popular concept today, but if we see the design principals of vernacular architecture, we can understand that sustainability is not a new topic. Even though the vernacular architecture of any place in the world follow more sustainable design principals, the architecture around the world keeps changing according to the development and the change in the culture and comfort of people. Along with these changes we move on and forget what the architecture used to be in that place. The change in architecture is not always in the right direction. It is not always in the wrong direction either. The purpose of this research is to understand the reason behind the change in the architecture of Marpha, Mustang and analyze either that change is in the right way or not.

To understand the changes and the result of those changes, the contemporary architecture of Jomsom was studied, the common design principals of the contemporary architecture is listed out and then those changes are implied on the same case study vernacular architecture studied before. The common design principals of contemporary architecture are listed as below:

Figure 63: Contemporary Architecture of Jomsom

- The building standing along without attached walls with the surrounding building.
- The fencing around the building was uncommon before while in contemporary buildings the fencing was found.
- Two or more stories building without courtyard.

- RCC structure building where brick, cement, steel, and concrete are the main building materials.
- Big windows all around the buildings.
- Shading devices all around the building.
- High Ceiling height.
- Stone, brick or paint finishing.

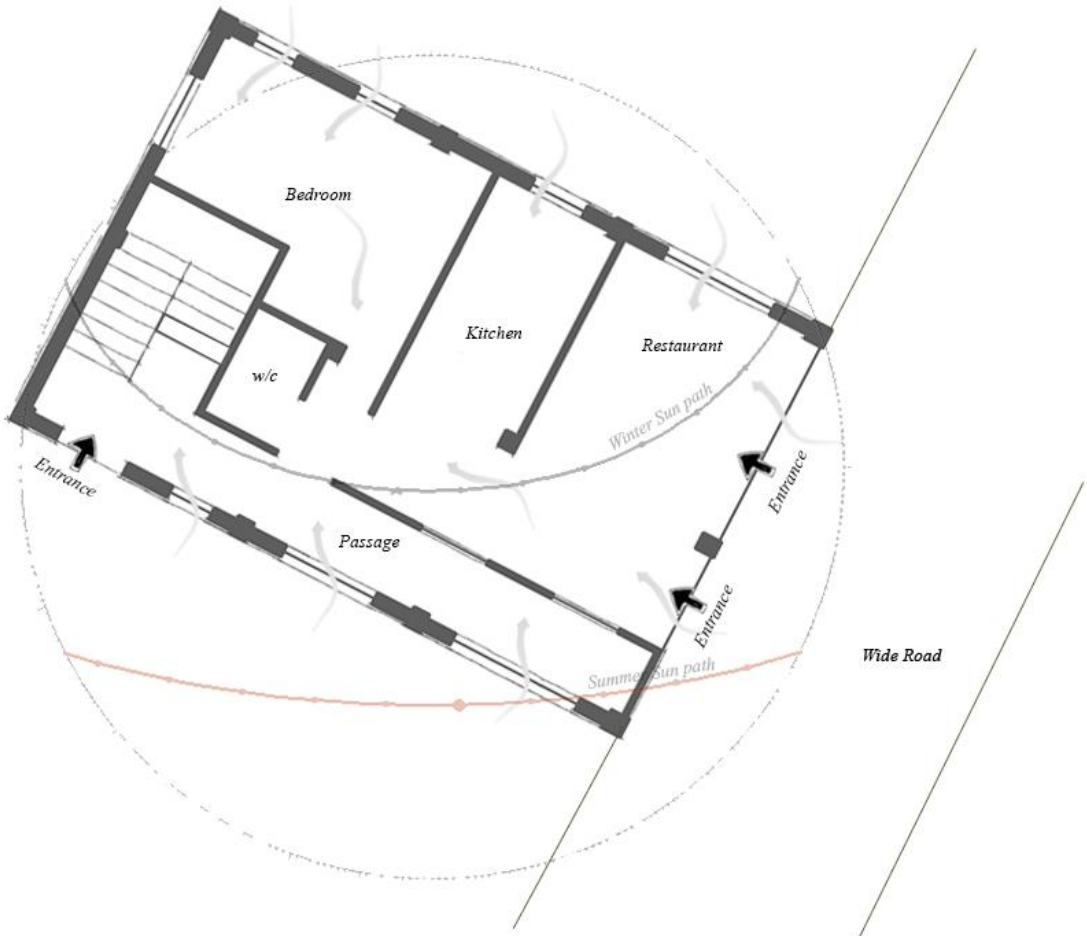


Figure 64: Ground floor plan

The case study building was changed to contemporary architecture. The building is changed to linear in shape without the courtyard. The building is standing alone with windows on all sides. The building layout is changed as shown in Figure 64 and Figure 65 with the restaurant, kitchen, and bedroom on the ground floor and rooms on the upper floor.

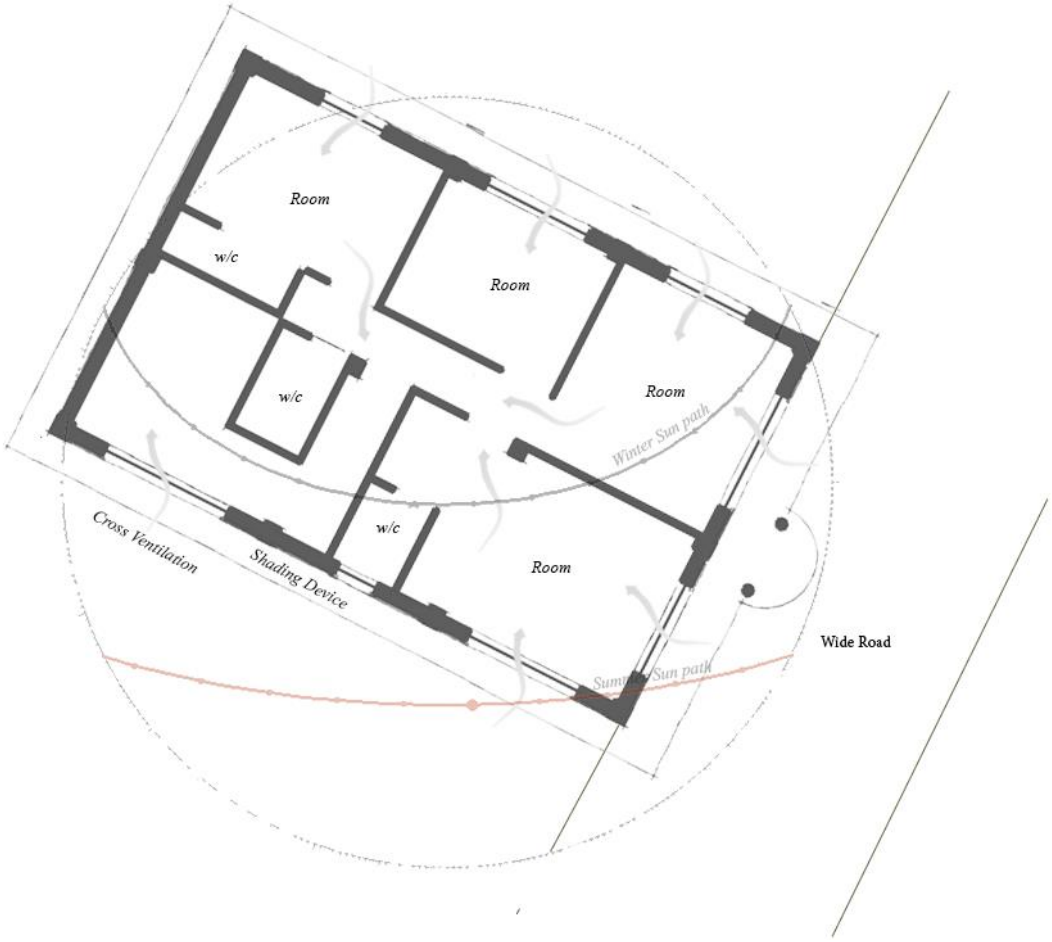


Figure 65: First Floor plan

BUILDING ORIENTATION AND SOLAR STUDY

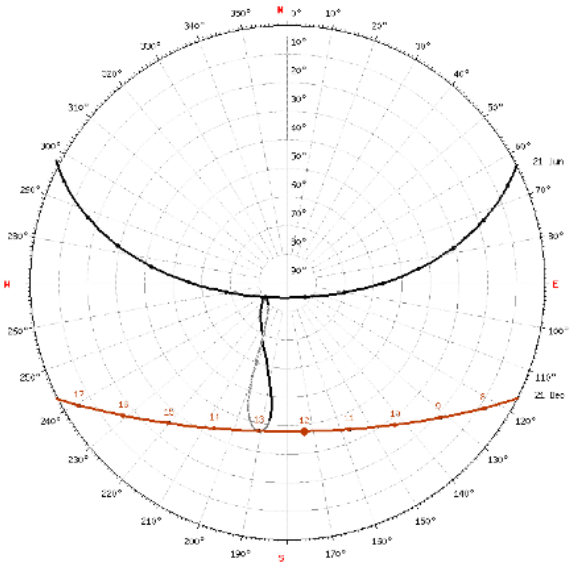


Figure 66: Shadow mask for December

The shadow mask of the building was again analyzed without the surrounding buildings to understand the solar radiation and the daylighting. As shown in Figure 66 the building has sun exposure from 7:00 am to 5:30 pm in December. In September, the building is exposed to the sun from 6:00 am to 6:15 pm while in June the building is exposed to the sun from 5:30 am to 9:30 pm as shown in Figure 68 and **Error! Reference source n ot found.**.

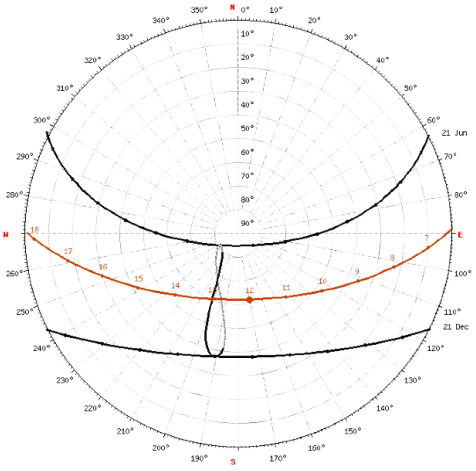


Figure 67: Shadow mask for September

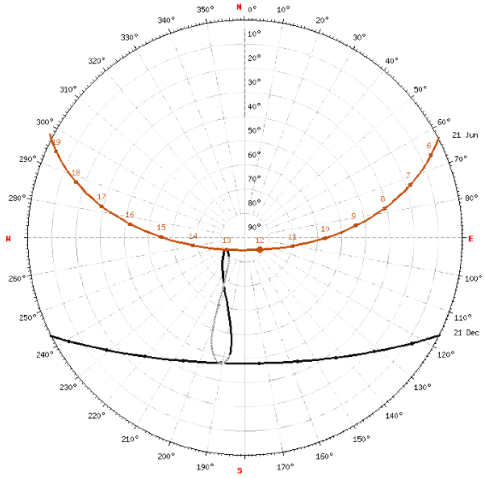


Figure 68: Shadow mask for June

The contemporary building has solar exposure from sunrise to sunset and since the building has opened on all sides, the rooms are exposed to the sun throughout the year. Along with sun exposure, air infiltration and wind penetration are also high in contemporary architecture. The wind being another main problem along with the cold, the contemporary architecture seems to be focused more on the cold and not considering the wind factor. The openings on either side of the wall increase the cross circulation of the air which is not the ideal design strategy for this climatic zone.

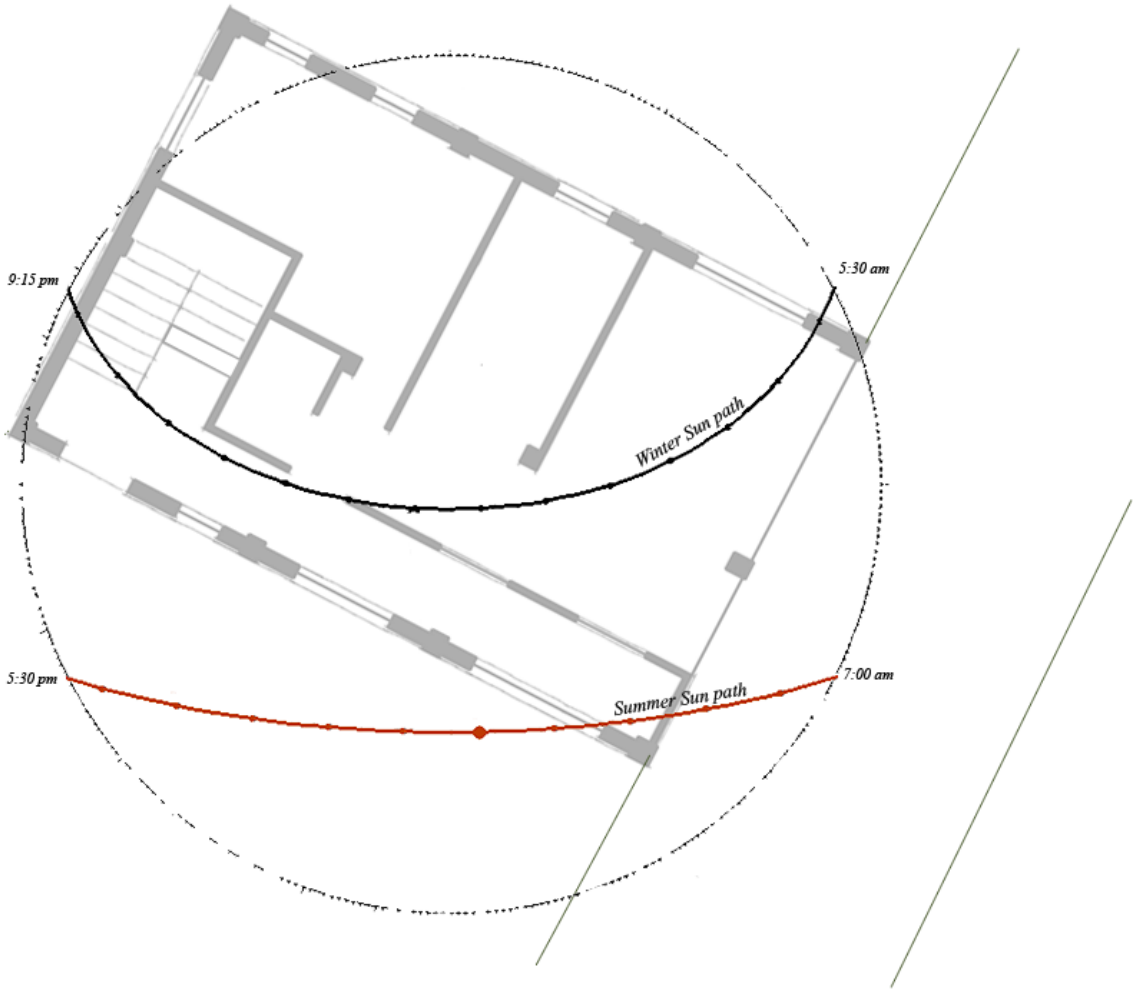


Figure 69: Shadow mask at ground floor

The heat exchange between the building and the surrounding environment is high which means there is more heat loss in the environment from the building. The shading device on west and east on shades building during morning and evening, while on the south building is shaded completely.

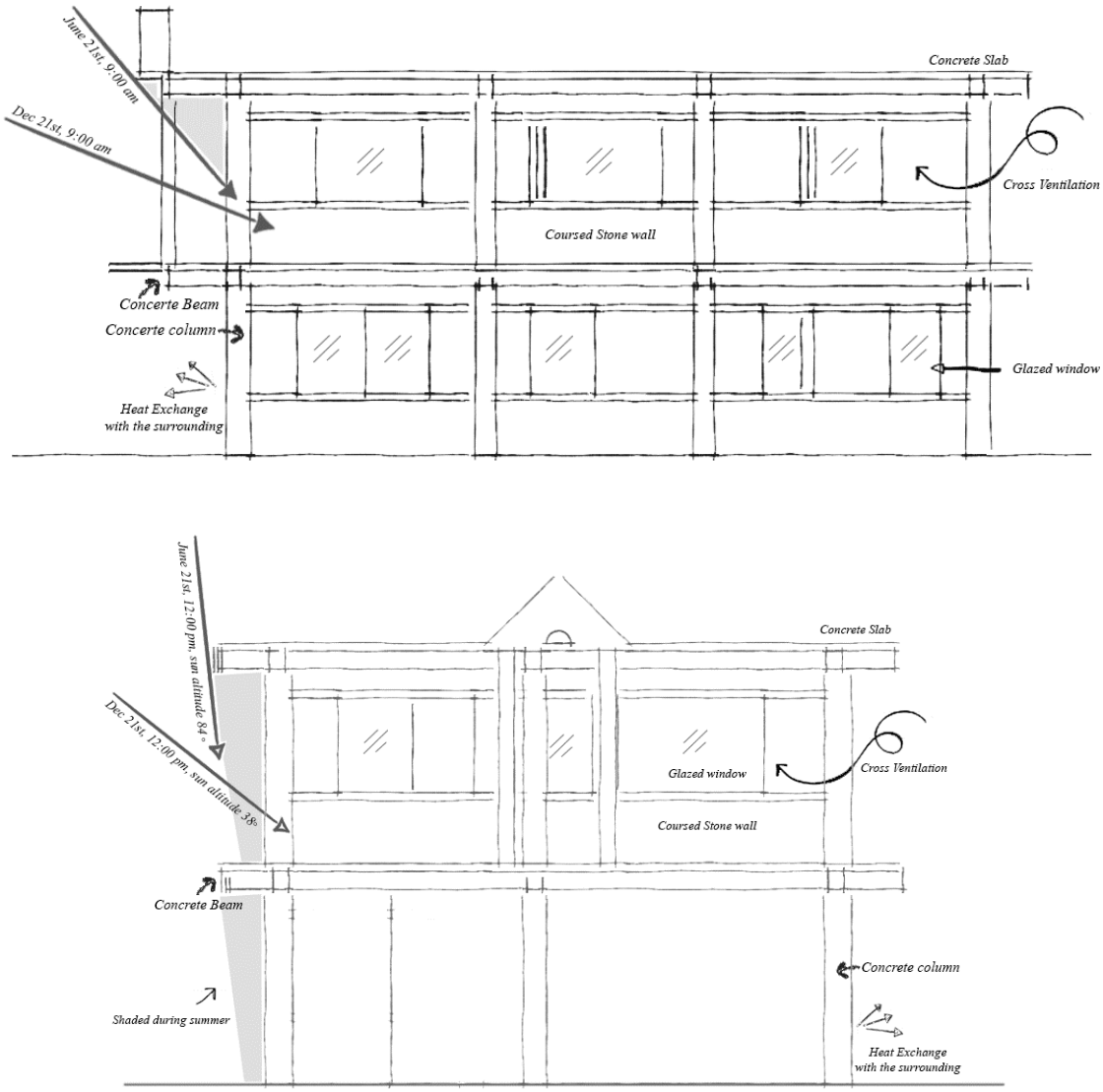


Figure 70: Elevation of the contemporary architecture

The ceiling height of the contemporary architecture is high which means the hot air rises and since the window is big with the ventilation at the top the warm air escapes from the building lowering the room temperature.

DAYLIGHT

The daylight in contemporary architecture is more in than the vernacular architecture which is certainly the better design strategies. No matter the place, culture or the climate, we always need good daylight for healthy living. The wide big window on all wall around the building welcomes good quality of light. Since the building is standing alone and not attached to another building the light is not disturbed in anyways. The daylight is analyzed by using the software SketchUp and plugin DeLuminae as shown in Figure 71.

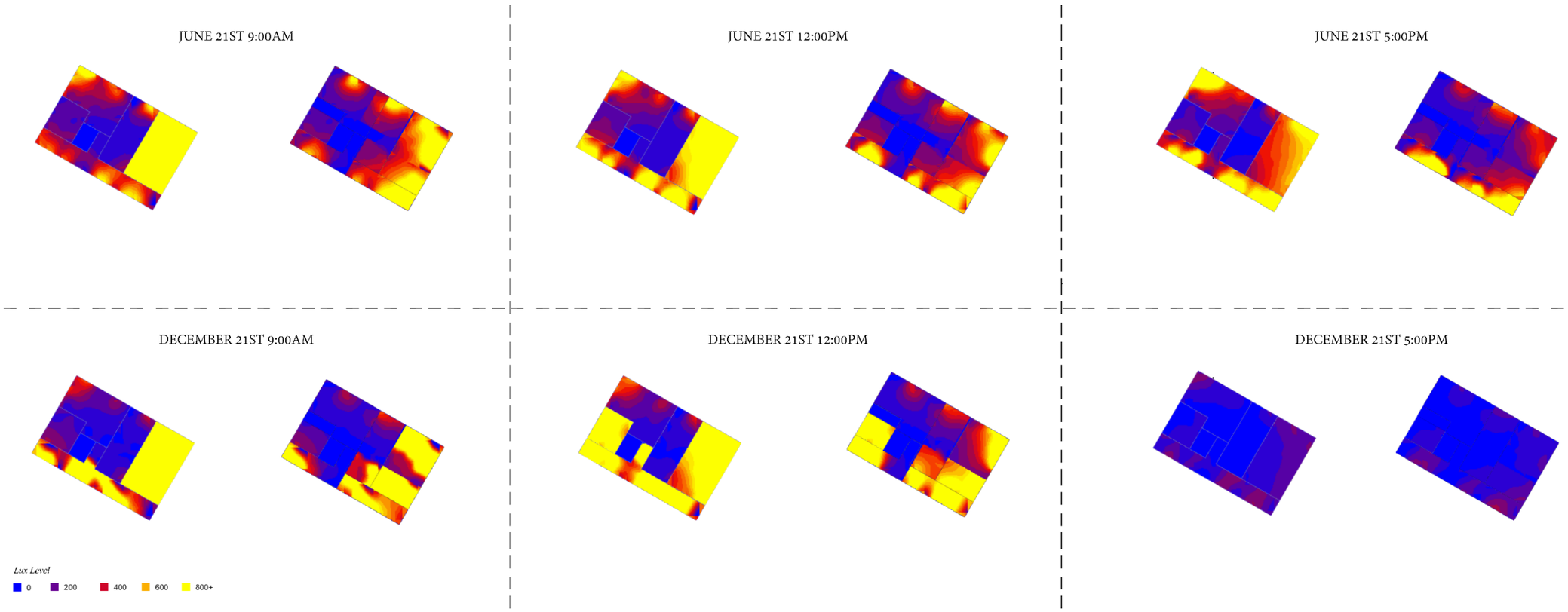


Figure 71: Daylight Autonomy for contemporary architecture

ENERGY

The simulation that was run previously with the design attributes of vernacular architecture was run again with the added internal heating load to study the indoor temperature and compare it with the thermal comfort.

According to the simulation and analysis, we can conclude that the minimum internal heating source is required for the comfort of the people in the building. The parametric analysis was done in the same simulation, by changing the orientation and thermal properties of the materials in the vernacular architecture along with the addition of the internal heat load. The energy use of the building was similar in all orientation because the building is almost square. With the change in the properties of the material, the energy use was increase by 14%.

Table 7: Indoor Temperature and hours per year with internal heating load

Zone	Unmet Htg (hr)	Unmet Htg - Occ (hr)	< 56 (F)	56-61 (F)	61-66 (F)	66-68 (F)	68-70 (F)	70-72 (F)	72-74 (F)	74-76 (F)	76-78 (F)	78-83 (F)	83-88 (F)	>= 88 (F)	Unmet Clg (hr)	Unmet Clg - Occ (hr)	Mean Temp (F)
THERMAL ZONE BEDROOM	4909	1332	0	170	2527	566	568	462	459	1275	2271	385	74	3	645	59	71.1 (F)
THERMAL ZONE KITCHEN	0	0	1218	1364	2958	547	428	420	340	263	235	490	321	176	0	0	65.6 (F)
THERMAL ZONE LIVING	4600	4530	0	160	1781	244	263	351	1475	1710	2419	305	51	1	565	534	72.3 (F)
THERMAL ZONE STORE	0	0	2113	2373	3137	564	341	183	46	3	0	0	0	0	0	0	60.6 (F)

MATERIAL AND RESOURCES

The building materials are changed from stone to brick and RCC (Reinforced Cement Concrete) construction. The walls are constructed of bricks with RCC slabs. The steel bar and concrete columns are the structural members with the cement plaster paint, marbles, tiles, parquets, textured plaster as finishing material.

Table 8: Showing the Material used in contemporary architecture

Material's Name	Availability	Note
Cement Blocks	Transported from nearby cities	Cement transported from nearby cities and missed with sand from river
Bricks	Transported from nearby cities	-
Cement	Transported from nearby cities	-
Steel rods	Transported from nearby cities	-
CGI Sheets	Transported from nearby cities	Not very common, mostly used in Government buildings
Glasses	Transported from nearby cities	-
Finishing material	Transported from nearby cities	Paint, marbles, tiles, parquets, textured plaster.

Figure 72: Sonam Gurung's Hotel

Owner Sonam Gurung said, "The four and a half stories tall hotel is targeted to tourist and tourism development with all the luxuries." He further added, "All the materials were brought from the Pokhara, even the workers were not from here and buildings from Pokhara and Kathmandu have influenced me to build this kind of designed hotel."[36]

The materials like brick, cement, steel rods, CGI sheets, Glasses are all imported from the nearby cities. All these materials are not available in nature so along with the transportation cost and energy, the energy and cost are invested in the manufacturing of the material, making new construction less energy efficient. As Sonam Gurung said, not only the material the workers are also imported from the cities making the new construction more expensive. These materials are in an open loop system where materials are imported from nature, manufactured, used and then thrown away in the form of pollution.

[36] *Raj Kumar, K. et al. (2014) Jomsom Settlement Study. Settlement Planning Course Report. Nepal Engineering College.*

Influences for the changes in the Settlement and Architecture

The changes in the society are inevitable and these changes are driven by different factors of the society. In this research, the changes in the settlement of Marpha and Jomsom are analyzed to understand the reason behind changes and the importance of the changes in the settlement.

INFRASTRUCTURE

Infrastructure and development are one of the main reasons for the changes in society. The importance and the influences of the infrastructure can be seen properly in the developing countries. Small development can result in big influences and impacts. After visiting the village, we understand that the construction of the Beni-Jomsom road played an important role in reshaping of the settlement. The development of the road leads to the possibilities that villagers never experience before. Along with the road, the development of Jomsom airport is another important infrastructure that connected these settlements to the outside world.

The development of the road and airport in the rural village of the underdeveloped country is the biggest achievement but after talking with many people of Marpha, we came to the realization that development of infrastructure does not always have the positive impacts. Before the construction of the road, people used to walk through Marpha to reach to the famous tourist and religious spot Muktinath. Marpha being on the trek route to the different mountain had different possibilities of businesses. Most of the people were dependent on the tourism business like shops, hotel, restaurant, etc. But after the construction of the road and airport, people get direct access to Jomsom and then to Muktinath without passing through Marpha. For the people of Marpha that caused huge economic downhill. People who were dependent on tourism had to migrate or adapt to new business. While it caused a negative impact on the people who were dependent on tourism, it was good news for people who were dependent on agriculture. The easy and quick access

to the city opened the possibility of export business. Marpha is famous for its apple and with the construction of rod and airport people were able to export fresh apple within one-two days to the cities. Many people were dependent on business so in average the economy of Marpha went down.

In term of architecture and the settlement, the construction of road and airport introduced a whole new perspective of development. After the construction of the road, the new buildings were started to be built along the roadside, which forced the change in the shape of the settlement from the compact to linear. In the compact settlement, there was less heat loss, less penetration of the wind, everything in the settlement was within the walking distance, the community was dense and sustainable. Now, the people want to build their house alongside the road for the better business opportunity, resulting in the change in the shape of settlement into a linear form. In the new linear shape settlement, buildings are only attached to each other only on one side. There is more heat loss between building and environment, more introduction of wind inside the settlement, less dense community, the walking distance increases leading to the decrease in walkability and increase in the use of the different mode of transportation and many other factors. Connecting the village with the cities and the world introduced a new method of construction and designs. For the people of Marpha and Jomsom, the architecture, facilities, and lifestyle of cities like Pokhara or Kathmandu are more sophisticated, and they want to change their lifestyle, their houses and develop their community like the cities.

> *"How can we say no to the road?" says Lama Ngawang Kunga Bista, a senior Buddhist monk and chairman of the Upper Mustang Welfare Committee. "The local people want modern facilities. We, who know how life is in Kathmandu and in Pokhara, how can we say no?"*[37]

It is natural that people of villages look up to people of cities and try to change their lifestyle. In the 21st century, infrastructure like road, transportation, internet, electricity,

[37] *Nina, W. (Accessed on 07 March 2019) Modernizing Mustang: A Hidden Tibetan Kingdom Meets Its Future, Global Oneness Project. Available at: https://www.globalonenessproject.org/library/articles/modernizing-mustang-hidden-tibetan-kingdom-meets-its-future.*

etc. has been part of our life as a basic need. We can't imagine our life without these infrastructures. Having proper road and transportation is a right of every citizen but the impact of the infrastructure should also a concern to the community, society, and government. Marpha and Jomsom are one example where we can see both negative and positive impacts on the settlement. In term of sustainability, development of infrastructures causes many negative impacts.

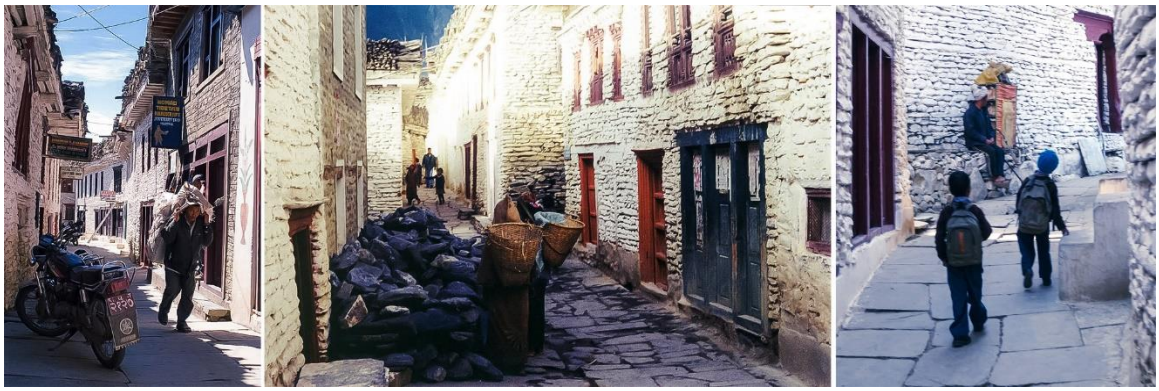


Figure 73: Inner road of Marpha

In Figure 73 we can see some of the positive and negative impacts of the road. The roads introduced different new possibilities and opportunities like in the figure, it encourages children to go to better schools but along with positive, there are many negative impacts too. The inner road of Marpha is designed and constructed for the pedestrian. The width of the road is narrow, the road pattern is curve and irregular. These road patterns and the design of the road is not appropriate for the vehicles. But due to the construction of Beni-Jomsom road, people can come by motorbikes or car inside the village. The stone-paved road is wearing down due to the use of the vehicles. Since the stone is locally available material there was no impact on the environment for the construction of the road. But if we take an example of Jomsom, the settlement went through the same pattern of change. The road introduced vehicle, the stone-paved road was not appropriate for the vehicle, so people started to construct concrete roads by bringing material from outside and generating lots of pollution.

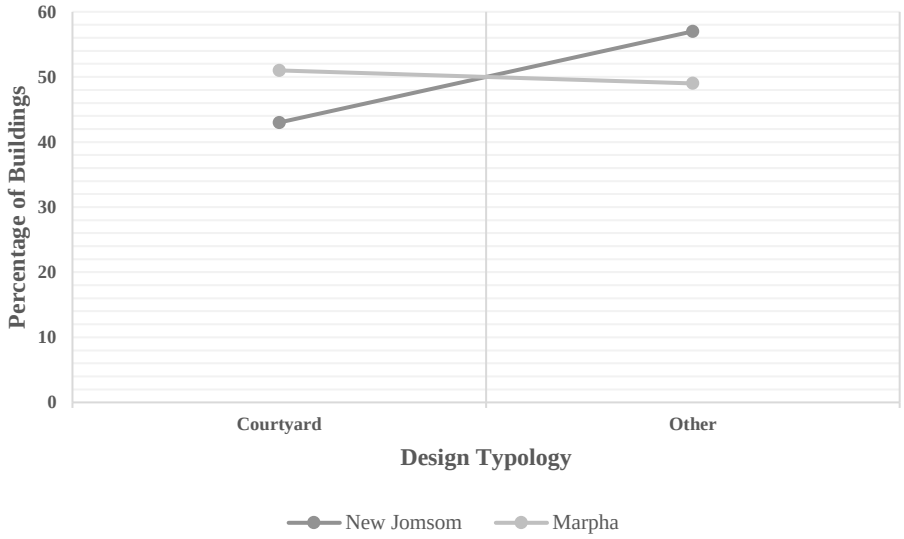
One of the main carbon emissions is underdeveloped countries is from vehicles. More the use of vehicles, more the negative impact on the settlement. While the developed countries are trying to make communities dense, increase walkability, design road for pedestrian, the village of an underdeveloped country like Marpha is moving in the opposite direction.

CLIMATE CHANGE

Climate change is one of the critical issues we are dealing in the world today. We all today know that the climate is changing since the past few years and the pace of change in climate is increasing day by day. The impact of climate change is huge, and in many cases, it is not traceable. In the village of mountains, we can see the impact of climate changes and the influences those changes caused on the lifestyle of the people. The Mustang once known as the desert of Nepal used to have no rain at all. But now due to the change in climate every day after 4:00 pm it rains. During our research, every day we faced rain after 4:00 pm which was surprising for us.

Rain is a good change for agriculture. The rainfall opens different opportunities of different plants and increases productivity resulting in an increase in the economy of the village. But in term of settlement and the architecture, rain introduced the new design typology. Since there was no rain before, buildings were made of mud and stone, the buildings had a courtyard in them, the whole village had wood stored on the terrace as the unique identity and above all, there was no proper drainage system. Due to the change in climate building was leaking and most of the buildings required maintenance. Not only the buildings but also the drainage system of the settlement was also not designed for the rain. Enough though there is a drainage system in the village, the rainwater is collected and run off to the river. While most of the building materials are from nature and the lifestyle of people does not have any chemicals and harmful pollutant, running rainwater to river is an ideal solution but now when the roads and buildings are constructed with the factory-made materials with different harmful pollutants, running rainwater through them and then mixing it to the rive cause river pollution.

When it started to rain in Jomsom, people started to cover their courtyard. Since the buildings were constructed of mud and stone, the water without proper drainage caused a major problem. The closed courtyard i.e. atrium was introduced but later people preferred to designed building without atrium and the courtyard to maximize the useable area. The same pattern can be seen in the Marpha. Most of the courtyards are already closed with plastic or glass and new buildings are constructed without courtyard or atrium. The character and the uniqueness of the architecture of these villages are changing due to climate change.



Graph 22: Showing change in Design Typology in New Jomsom and Marpha

CHANGE IN CULTURE

The culture plays an important role in the design and the development of any settlement. The culture of Marpha and Jomsom is changing. The way people used to live is now changed. From how people used to live, what they used to eat, how they used to wear to what they do, what they expect from society and their priorities have been changed. People used to wear their cultural dress, they used to talk in their own language, they used to eat all their own agricultural products, they used to walk everywhere, they used to do

their own business or agriculture, for them, comfort was to live in peace and happiness while today people wear western dresses, they don't know their cultural language and everyone speaks Nepali, people prefer different foods from all around and agricultural products are not enough and for them, luxury is comfort. This changes in culture reshape the settlement and the living standards.

For example, People used to live in a community like family. Everyone knew each other, they helped each other, they share things with each other which encouraged the compact settlement planning but now people prefer privacy more. So, we can see that the building now is designed with the fencing around them. The place where buildings used to share walls, now has building away from each other with fencing around and the culture of people plays an important role in these changes.

LIVING STANDARD

After my research, I think the change in the living standard of the people is another influence for the change in settlement and the architecture. If we see at the demography of this place, most of the people are old or young with their son or/and daughter living/studying/working in cities or foreign countries. While a member of the family works in cities or foreign countries there are a couple of impacts that are caused in the family: 1. They want to repair, redesign or rebuild their home with the design that they see or live in city or different country 2. They want the same quality of life and comfort for them and their family and 3. They want to show their economic development in society and stand out. These factors are important for this research because it causes a change in the architecture and the settlement.

When people move to a new place especially from village to cities, they see the new design and more comfortable living standard. It is obvious for them to think that those buildings and designs are more comfortable, and they want to redesign or repair their old houses as per their experience to produce comfort to their family. But the design of

buildings varies from place to place, from climate to climate, from culture to culture which is usually not considered by people. When people with high economic status introduce a new design in building the people of low economic status look up to them and try to compete with them. The good example of it will be, in Jomsom building built with concrete and steel are considered as more sophisticated and more comfortable and people with those building designs are considered more economically stable and rich. So, when in these villages one way to show their economic development is to change buildings into new modern contemporary architecture but unfortunately for that climate and location modern contemporary architecture are less sustainable.

Along with the change in architecture, people want to have a change in living standard too. For example, buying a car in the village in this is not only about luxury but also about showing off wealth and prosperity. Even though most of part of the village is in walking distance, youth in these villages are leaning towards commuting through motorbikes and cars because it will make them stand out. If most of the youth commute by vehicle then the roads and other infrastructures should be also changed accordingly. Change in living standard and the race of showing economic development is one of the competitive reasons for the change in society and it will cause change faster than other reasons.

TOURISM

Tourism is one of the most important business in Nepal. Mustang has become one of the famous destinations in 2018/19 with both domestic and foreign tourists. Unlike other business, tourism is one of the influential business which can cause a major impact on the culture of the people. When some foreign people visit a place like Marpha or Jomsom with a different culture, people of those villages tend to get influenced by the way tourist act, live, talk, dress, eat, etc. which helps them to get attract toward foreign culture. Those are

the influences in personal level which might cause big results like people migrating to city or foreign countries seeking for a better life.

One of the biggest direct impacts of tourism is architecture and settlement is that, since different people come to visit these places, people who own business like restaurant or hotel would compete to provide the best facility to their customers. One of the new trends of competition among business owner is building their property with contemporary architecture with foreign materials. They believe that RCC structures like Kathmandu and Pokhara will attract tourist to their business which is not wrong. When people go on vacation, they prefer luxury and since wealthy people own such property it is easy to understand that those buildings will accommodate more facility and luxury.

Not only a change in architecture and settlement, but tourism also causes influence in the culture. One of the examples of this could be, people from village where they always live with their parents and people from different culture where they live alone from age of 18 met and share their culture with each other, people from village might feel like people from different culture have more freedom and independence and opportunity for personal growth and eventually it might influence them to have separate home from their parents. According to our survey, most of the families in these villages are already nuclear family and influence from tourist has some contribution towards that data. Change in culture from joint family to nuclear increase the number of buildings increasing the sprawl.

BUILDING STANDARDS

One of the key factors to control the influences and impact from different sources is to have to proper build code and bylaws. Unfortunately, the lack of proper codes and laws is encouraging the uncontrolled experiments on the buildings and settlement. The government should be responsible for the preparation and implementation of the proper

bylaws and building code but currently, there is no such codes and laws providing people the freedom to design as per their desire without any constrains.

MARKET VALUE

The market value of architecture plays another important role in reshaping the architecture of any place. The market value of vernacular architecture is low in Marpha and Jomsom. Most of the vernacular architecture is more than 100 years old and their condition needs attention now. So, the market value is low while the market value for contemporary architecture is high because of the expensive material, expensive construction practice and the fact that their age is less than 50 years and they are new in the settlement. People will always construct building with the design which has a high market value so that in future if they need to sell it then they will get the good value of the property. In Marpha and Jomsom the market value of contemporary architecture I high which encourage people to change their architecture.

Comparison between Vernacular and Contemporary Architecture

Both the vernacular and contemporary architecture were studied and analyzed in term of building orientation, daylight, energy, and material and resources. The comparison between the design strategies is shown in the table below.

As we can see in Table 9, some design strategies are more sustainable in vernacular architecture while some of them are more sustainable in contemporary. The building orientation of vernacular architecture is square with a courtyard and more favorable in this type of climate. The settlement is more compact with less heat loss and low wind penetration in vernacular. The cross ventilation is avoided in vernacular while in contemporary more wind is introduced in a building which is not recommended for this

climate. The energy in term of comfort is more desirable in contemporary architecture. The size of opening and daylighting is more favorable in contemporary architecture. The shading devices are not required in this climate for the sun protection but due to the climate change, it is required for the rain protection so both design strategies are correct in their timeline. The floor to ceiling height and heat loss is more favorable in vernacular architecture. The materials and resources are a lot more sustainable in vernacular architecture as vernacular architecture used locally available materials with a closed-loop system.

Table 9: Comparison of design strategies

	VERNACULAR ARCHITECTURE	CONTEMPORARY ARCHITECTURE
Building Orientation	●	
Settlement (Spacing)	●	
Cross Ventilation	●	
Heat loss	●	
Energy (Comfort)		●
Daylight		●
Size of Opening		●
Shading Devices (Protection from sun and rain)	●	●
Floor to Ceiling Height	●	
Materials and resources	●	

Chapter 6: Design Recommendation and Conclusion

For the design recommendation at Marpha, three different approaches were adopted. The Mahoney Table was used to conclude the design strategies at the given place with the given climate. The bioclimatic chart by Victor Olgyay was used to compare and further confirm the design strategies by Mahoney Table. Then the psychrometric chart was used to gather more design idea and recommendation.

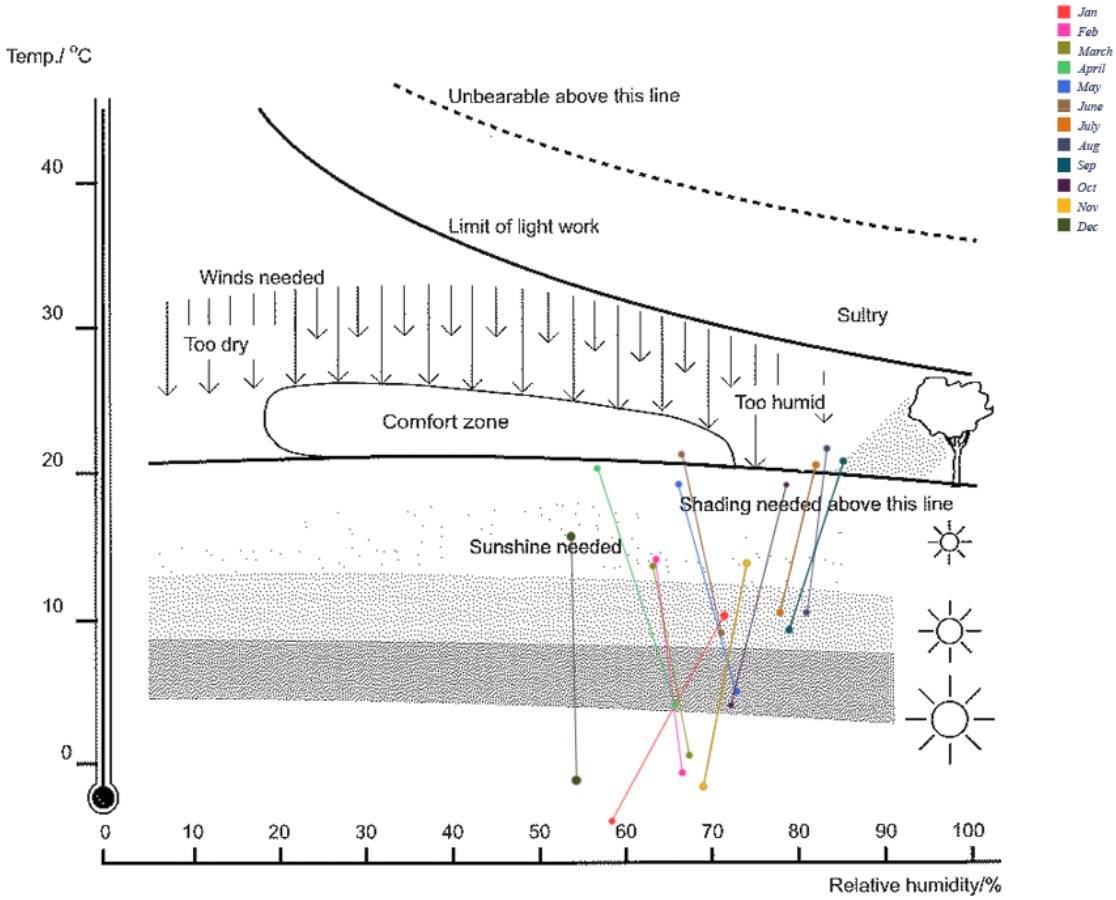


Figure 74: Bioclimatic Chart for Marpha

From the bioclimatic chart above, we can see that most of the time throughout the year is below the comfort zone. The one of the design recommendations we can get from above chart is that the sunshine is required in the building. The building should be designed

in such a way that the maximum solar radiation should be encouraged. We can also see that for four months during maximum temperature shading device is recommended for the building. Thus, the design recommendation from the bioclimatic chart are:

1. ***Maximize solar radiation***
2. ***Provide shading device for four months of the year***

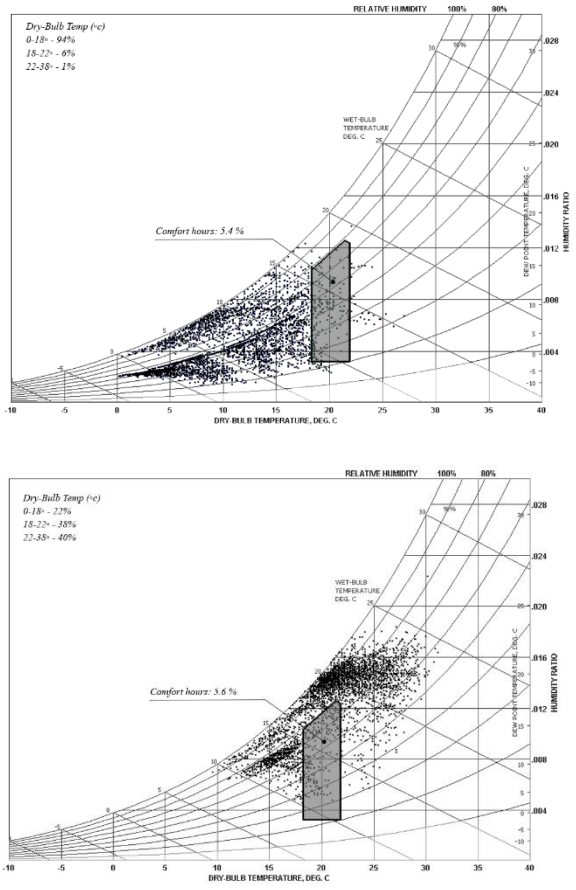


Figure 75: Showing comfort for summer and winter

In the Figure 75, we can see that the comfort hours during winter and summer are 5.4% and 5.6% respectively. From this psychrometric chart, we can conclude that in open environment without any design strategies, people are uncomfortable for almost 95% of time.

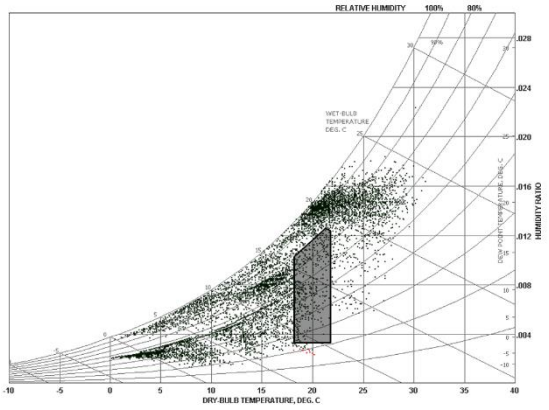


Figure 76: Psychrometric Chart showing comfort and temperature throughout the year

From the psychrometric chart as shown in the Figure 77, we can conclude different design recommendations for architecture in Marpha. Heating, internal heat gain, passive solar heat gain with high mass are the important design recommendation form

psychrometric chart. Along with them natural ventilation for cooling is also recommendation which I believe is because of the limitation of the psychrometric chart to incorporate the wind and gust. The list of the design recommendations from the psychrometric chart are listed below:

1. ***For 483 hours, people will feel comfortable without any strategies.***
2. ***For 1402 hours, sun shading is recommended in the building.***
3. ***For 166 hours, the high thermal mass is recommended to provide in the building.***
4. ***For 1533 hours, natural ventilation is suggested to provide for the cooling.***
5. ***For 2167 hours, internal heat gain is recommended.***
6. ***For 1418 hours, passive solar heat gain with high thermal mass is recommended.***
7. ***For 337 hours, wind protection is recommended to provide in the building.***
8. ***For 683 hours, cooling and dehumidification is recommended.***
9. ***For 2227 hours, heating and humidification if required is recommended.***

The Psychrometric chart provides all these recommendation on the basic of the climatic data provided. As already explained before, the limitation of proper and authentic climatic data has been the challenge for this research. For this research the climatic data were collected from different sources: Government, online weather websites and Meteonorm software, complied them in the excel file and then created a.epw format with the help of the software Element. The following chart was created from the same .epw file created.

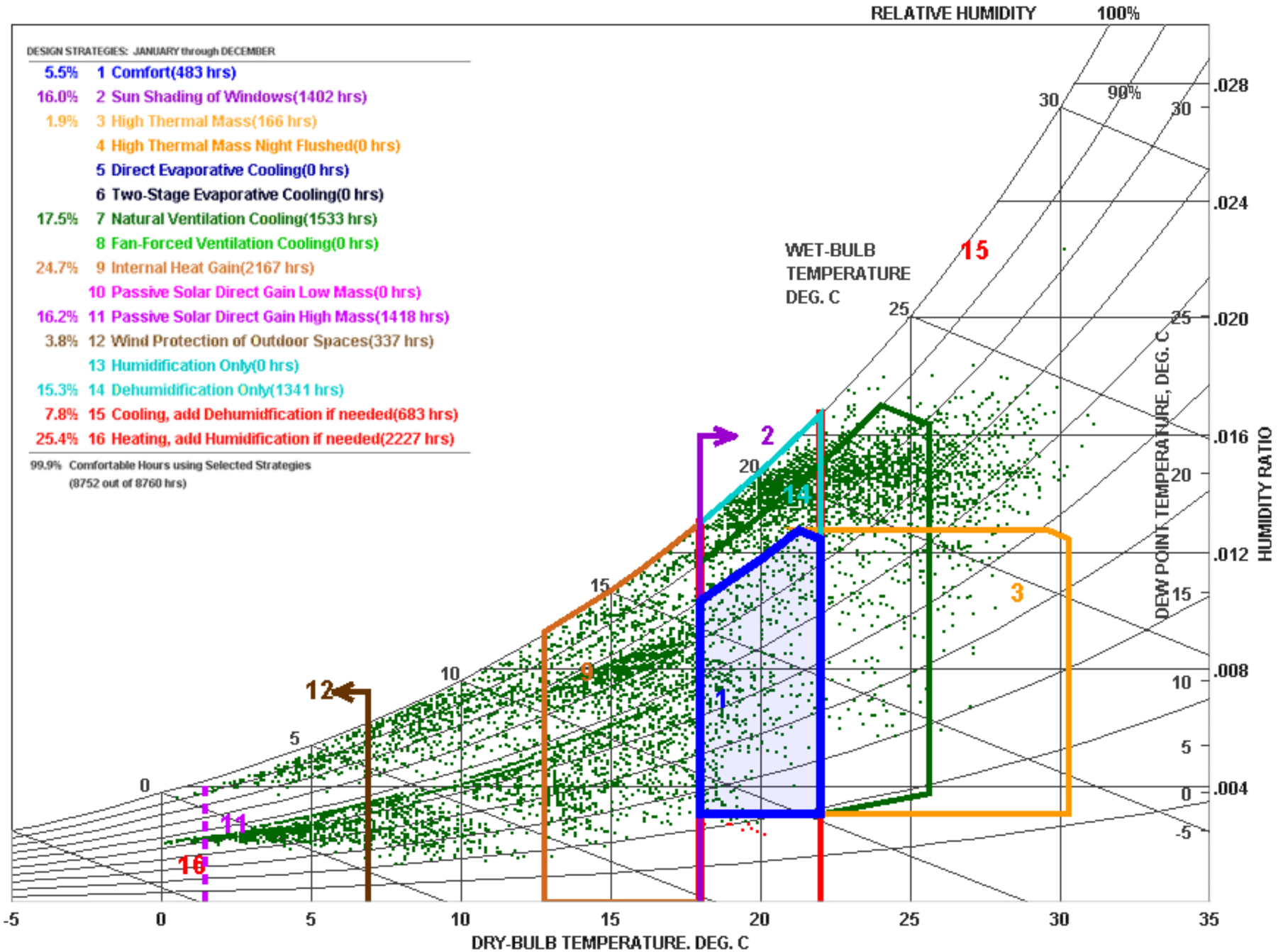


Figure 77: Psychrometric chart with design recommendation

Table 10: Mahoney Table for Marpha

Location	Marpha, Nepal
Latitude	28.8151° N
Longitude	83.6455° E
Altitude	2650 m

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
11	14	14	20	19	22	22	22	22	20	15	16
-4	-1	0	4	5	10	12	12	9	5	-1	-2
15	15	14	16	14	12	10	10	13	15	16	18

High	AMT
22.00	**9.00**
-4.00	**8.00**
Low	AMR

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
71.8	63.7	63.2	56.8	67.5	68	83.2	83.9	85.5	79.6	73	52.6
59.3	67.1	68.8	66.7	72.9	71.3	78.8	80.4	79.3	72.4	69.8	54.5
65.55	65.4	66	61.75	70.2	69.65	81	82.15	82.4	76	71.4	53.55
3	3	3	3	4	3	4	4	4	4	4	3

Humidity Group			**If average RH**
	1	Below 30%	
	2	30-50%	
	3	50-70%	
	4	Above 70%	

Table 10, Cont.

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
13.28	6.32	44.91	119.3	169.3	195.4	662.33	414.2	152.6	14.86	2.44	3.34	**1798.28** **Total**
12.9	11.7	12.4	10	8	7.1	5.9	5.6	7.7	13	12	13.1	
W	W	W	W	S	S	S	S	S	S	W	W	
10.5	11.25	11.75	13	13.5	13.8	13.75	13.15	12.5	11.5	10.75	10.3	**12.15** **Mean**
92.5	95	127.5	140	140	132.5	100	102.5	109	107.5	89	84	**109.96** **Mean**

	AMT over 20◦C		AMT 15-20◦C		AMT below 15◦C		
Humidity Group	**Day**	**Night**	**Day**	**Night**	**Day**	**Night**	**Comfort Limits**
1	26-34	17-25	23-32	14-23	21-30	12-21	
2	25-31	17-24	22-30	14-22	20-27	12-20	
3	23-29	17-23	21-28	14-21	19-26	12-19	
4	22-27	17-21	20-25	14-20	18-24	12-18	

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	AMT
11	14	14	20	19	22	22	22	22	20	15	16	**9.00**
26	26	26	26	24	26	24	24	24	24	24	26	
19	19	19	19	18	19	18	18	18	18	18	19	
-4	-1	0	4	5	10	12	12	9	5	-1	-2	
19	19	19	19	18	19	18	18	18	18	18	19	

Table 10, cont.

12	12	12	12	12	12	12	12	12	12	12	12
C	C	C	O	O	O	O	O	O	O	C	C
C	C	C	C	C	C	O	O	C	C	C	C

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
				●		●	●	●	●			**0.00**
						●	●					**5.00**
●	●	●	●		●						●	**2.00**
●	●	●								●	●	**6.00**
												0.00
												5.00

Applicable when:	**Indicator**	**Thermal stress**		**Rainfall**	**Humidity group**	
Meaning		**Day**	**Night**			
Air Movement essential	H1	H			4	
		H			2,3	Less than 10
Air Movement desirable	H2	O			4	
Rain protection necessary	H3			Over 200mm		
Thermal capacity necessary	A1				1, 2, 3	More than 10
	A2		H		1, 2	

Table 10, cont.

Outdoor sleeping desirable				
		H	O	1,2
Protection from cold	A3	C		

H (Hot): If mean is above limit
O (Comfort): If mean is within limit
C (Cold): If mean is below limit

Indicator from Table 2								
H1	**H2**	**H3**	**A1**	**A2**	**A3**			
								LAYOUT
			0-10			•	1	Orientation north and south (long axis east-west)
			11, 12		5-12			
					0-4		2	Compact courtyard planning
								SPACING
11,12							3	Open space for breeze penetration
2-10							4	As 3, but protection from hot and cold winds
0,1						•	5	Compact layout of estates

Table 10, cont.

AIR MOVEMENT

3-12							6	Rooms single banked, permanent provision for air movement
1,2			0-5					
			6-12			•	7	Double banked rooms, temporary provision for air movement
0	2-10							
	0, 1						8	No air movement requirement

OPENINGS

			0, 1		0		9	Large Openings, 40-80%
			11, 12		0, 1		10	Very small openings, 10-20 %
Any other conditions						•	11	Medium openings, 20-40%

WALLS

			0- 2				12	Light walls, short time lag
			3-12			•	13	Heavy external and internal walls

Table10,cont.

ROOFS

			0- 5				14	Light, insulated roof
			6- 12			•	15	Heavy roofs, over 8 h time lag

OUTDOOR SLEEPING

				2- 12			16	Space for outdoor sleeping required

RAIN PROTECTION

		3-12					17	Protection from heavy rain necessary

SIZE OF OPENING

			0, 1		0		1	Large: 40-80%
					1-12	•	2	Medium: 25-40%
			2-5					
			6-10				3	Small: 15-25%
			11, 12		0-3		4	Very Small: 10-20 %
					4-12		5	Medium: 25-40%

Table10,cont.

PROTECTION OF OPENING

3-12							6	In north and south walls at body height on windward side
			0-5					
1-2			6-12			•	7	As above, opening also in internal walls
0	2-12							

PROTECTION OF OPENING

					0-2		8	Exclude direct sunlight
		2-12				•	9	Provide protection from rain

WALLS AND FLOORS

			0-2				10	Light, Low thermal capacity
			3-12			•	11	Heavy, over 8 h time lag

Table10,Cont.

ROOFS

			0-2				12	Light, reflecting surface, cavity
10-12			3-12				13	Light, well-insulated
			0-5					
0-9			6-12			•	14	Heavy, over 8 h time lag

EXTERNAL FEATURES

				1-12			15	Space for outdoor sleeping
		1-12				•	16	Adequate rainwater drainage

As shown in the table above, the Mahoney table was used for the analysis and the design recommendation. From the Mahoney table, the following sets of recommendations are concluded:

1. ***The building must have Orientation north and south (long axis east-west) to maximize the south sun and minimize the east-west glare.***
2. ***In term of spacing between the buildings, the compact settlement is recommended.***
3. ***For the air movement, double-banked rooms, temporary provision for air movement is recommended.***
4. ***Medium openings, 20-40% is recommended.***
5. ***For walls, heavy external and internal walls are recommended.***
1. ***Heavy roofs, over 8 h time lag is recommended for the roof, walls and the floor of the buildings.***
2. ***Provision of protection from rain is recommended with the adequate drainage system.***

CONCLUSION

After the literature review, field visit, data collection, analysis and design strategies analysis from three different approaches the following conclusions are drawn which is proposed as the design recommendation for the Marpha.

1. Square or rectangular building layout is recommended for the Marpha because of the cold weather with a north-south orientation to maximize the solar heat gain.
2. The compact settlement like before is recommended as it helps to reduce the heat loss from the building to the environment and to prevent wind penetration.
3. The courtyard design is a good strategy to increase solar heat gain but due to the climate change and increase in rainfall, the closed courtyard or the atrium from

where natural daylight and solar radiation can enter inside the building is encouraged.

4. The medium opening design recommendation from Mahoney table is appropriate for Marpha. Since we want to avoid the wind but want to increase the solar radiation and daylight, medium opening (20-40%) is recommended.
5. The shading device is not required for most of the time of the year. The maximum sun height during summer is 84◦ and for that angle no shading device is necessary. Hence, it is not recommended to design a shading device but if required shading device with short width is enough to shade the openings throughout the year depending on the building orientation.
6. The room height is recommended to keep low to reduce the heat loss from the living spaces.
7. The cross ventilation inside the room is recommended to avoid considering the cold and windy climate of the Marpha.
8. The wall and roof are recommended to design with the high thermal mass, that encourage the heat gain during the day, store heat and release during night.
9. The concept of not using ground floor living space in vernacular architecture is recommended to continue as there is maximum solar radiation, daylight and less heat loss to the ground in the first floor in comparison to the ground floor. Considering the culture of the place, most of the people have business at their own home so it is recommended to use the ground floor for business while upper stories for the living.
10. The material plays an important role in the sustainability of the building. The local materials like stone and wood are highly recommended to use as they don’t require any other energy for the production, transportation, and deposal. These materials are from nature and locally available which requires less energy and cost.

FURTHER RESEARCH

The above research demonstrates the data collection, analysis, and design recommendations. The research gives us the idea for the sustainable design in Marpha but there are different further researches needed to make sure how to implement them in the village area like Marpha.

The data collection, analysis, and the design recommendation are one part of the research, but we also need to understand the challenges for the implementation of recommended design strategies. This research intends to establish the ground for further research regarding the challenges for sustainable development in the least developed and developing country like Nepal.

The world today is divided into three in term of economy and industrialization: first world, second world, and third world. During the Cold War, the United States, Canada, South Kora, Japan, and Western European nations and allies were categorized as First World countries. Second World countries included China, Cuba, the Soviet Union, and their allies. Third World countries typically had colonial pasts in Asia, Africa, Latin America, and Oceania.[38]

These terminologies have changed into the least developed, developing and developed as these terms describe the economic, social, political and environmental situation of the country. According to the 2018 data, there are 144 developing countries and among them, 47 countries are considered least developed.[39] Since out of 195 countries, 144 are developing countries which is more than 73% it is important to understand where the development of these countries going.

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[38] *Third World Countries 2019 (no date) World Population Review. Available at: http://worldpopulationreview.com/countries/third-world-countries/.*

[39] *Third World Countries 2019 (no date) World Population Review. Available at: http://worldpopulationreview.com/countries/third-world-countries/.*

The first world countries or the developed countries are already in the path towards sustainability. There are different building codes, by-laws, different organizations and programs being implemented for the achievement of sustainability. U.S. Green Building Council and the LEED Green Building Programs are an example of the initiation for sustainability. While the first world/developed countries are already in the path towards sustainability, where the developing/least developed countries are is one the critical research question that needs attention and the study. Since more than 73% of the world is in the developing or underdeveloped it is important to understand where their development is going. According to the study, it would take four Earths - or to be precise, 3.9 Earths - to sustain a population of seven billion at American levels of consumption. [40] When we think about this ratio, it makes me wonder what will happen to the climate change and global warming if we all 7 billion people in the world developed in the same way and starts to consume a similar amount of energy. Further study could be conducted to understand these possibilities.

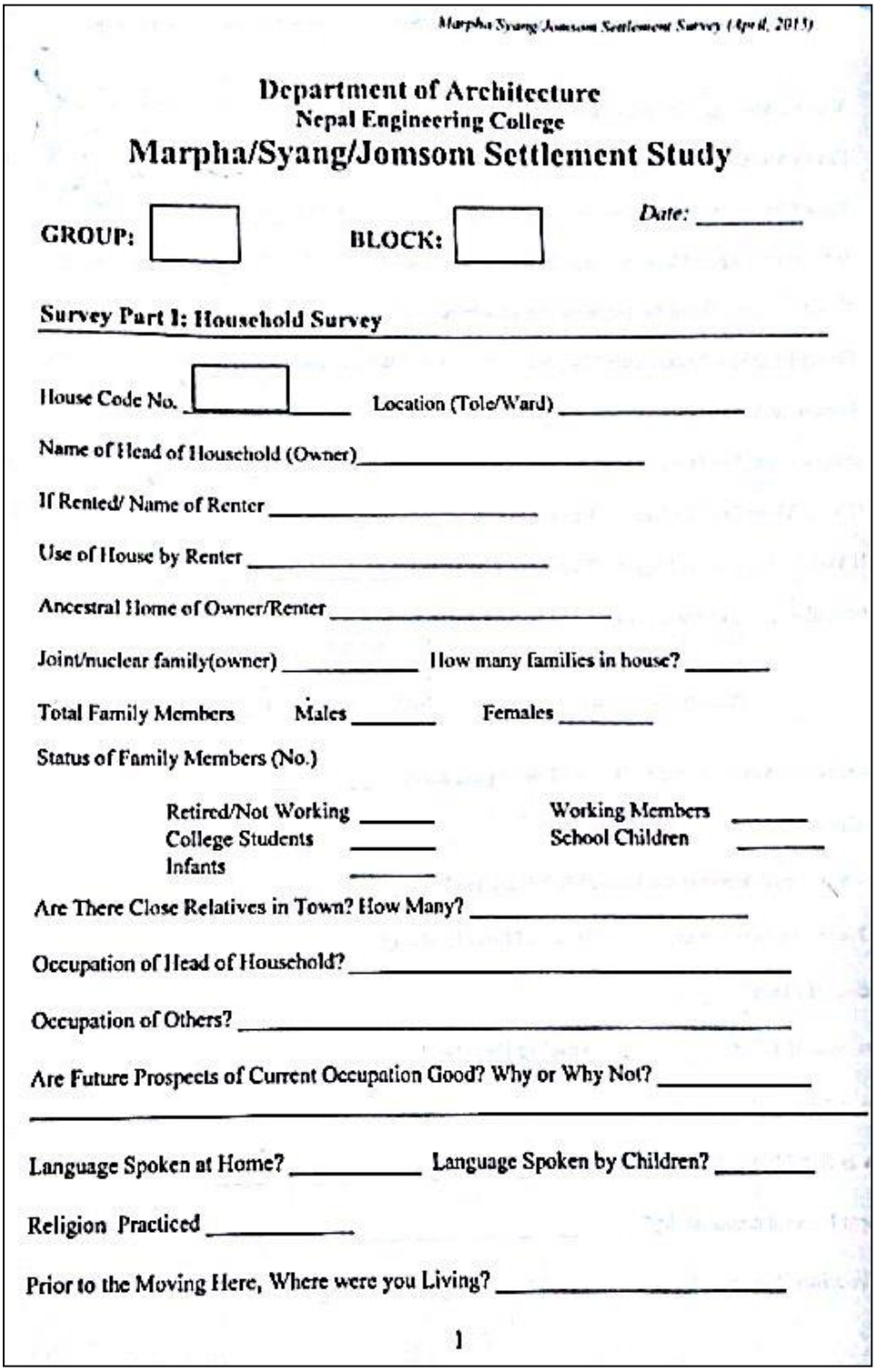
According to this research, we can conclude that architecture is changing without considering its impact on the climate and the environment. Further research could be done comparing the architectural growth and change in architecture pattern in the first world and second and third world countries to understand the difference and similarities between these patterns. After that understanding, we can conclude if second and third world countries are following the same pattern as first-world or not, and if it is then is there a chance that second or third world countries can skip some steps and jump to sustainability? Will the economy and politics of those countries will be able to support that.

Another important question that needs attention is how we can achieve sustainable development goals in developing or least developed countries. We can conduct research and analysis to understand the sustainability goals and design strategies for the better development of the architecture, but the real question is about how we can make them implemented in the economically, politically and culturally challenged society. The way

[40] *BBC News (2015) 'How many Earths do we need?', 16 June. Available at: https://www.bbc.com/news/magazine-33133712.*

architecture is changing in the second and third world is certainly away from the sustainability which is supported by this research. Even though different programs like LEED green building programs are internationally accepted the study is needed to understand if all the strategies on these programs are suitable for the developing or least developed countries so that we can solve the first world, second world, and third world problem together for the sustainability.

Appendix



Marpha Syang Jomsom Settlement Survey (April, 2015)

Department of Architecture
Nepal Engineering College
Marpha/Syang/Jomsom Settlement Study

GROUP: ☐ **BLOCK:** ☐ *Date:* _____

Survey Part I: Household Survey

House Code No. ☐ Location (Tole/Ward) _____

Name of Head of Household (Owner)_____

If Rented/ Name of Renter _____

Use of House by Renter _____

Ancestral Home of Owner/Renter _____

Joint/nuclear family(owner) _____ How many families in house? _____

Total Family Members Males _____ Females _____

Status of Family Members (No.)

Retired/Not Working _____ Working Members _____
College Students _____ School Children _____
Infants _____

Are There Close Relatives in Town? How Many? _____

Occupation of Head of Household? _____

Occupation of Others? _____

Are Future Prospects of Current Occupation Good? Why or Why Not? _____

Language Spoken at Home? _____ Language Spoken by Children? _____

Religion Practiced _____

Prior to the Moving Here, Where were you Living? _____

1

Figure 78: Showing Questionnaires used for survey

Why the Move to Present Location from Previous Home? _____

Family Members Temporarily Migrated _____ Where Migrated _____

Reason for Temporary Migration? _____

Is Migrated Family Member Supporting Family Financially? _____

How have you utilized the funds sent by Member? _____

Family Members Permanently Migrated _____ Where Resettled? _____

Reason for Emigration? _____

Do you Have Any Plans to Migrate Anytime in the Future? _____

If Yes, Where Do You Plan to Migrate? Why? _____

If You Do Not Plan to Migrate, What Makes You Stay? _____

Education Level of Family Members (No.)

Masters _____	High School _____
Bachelors _____	Intermediate _____
Primary/ Secondary _____	No formal Education _____

Member of Any Community Group? Tole Organizations? _____

Is Group Active? _____

Is There Piped Water in the House? Is It Sufficient? _____

Is There Electricity in the House? Hours of Load Shedding? _____

Source of Electricity _____

Provision of Toilet? _____ Attached/Detached? _____

How is Sewage Disposed? _____

How Is Solid Waste Disposed? _____

Is there Internet connectivity? _____

Has Tourism Benefited Your Village? How? _____

Figure 78, cont.

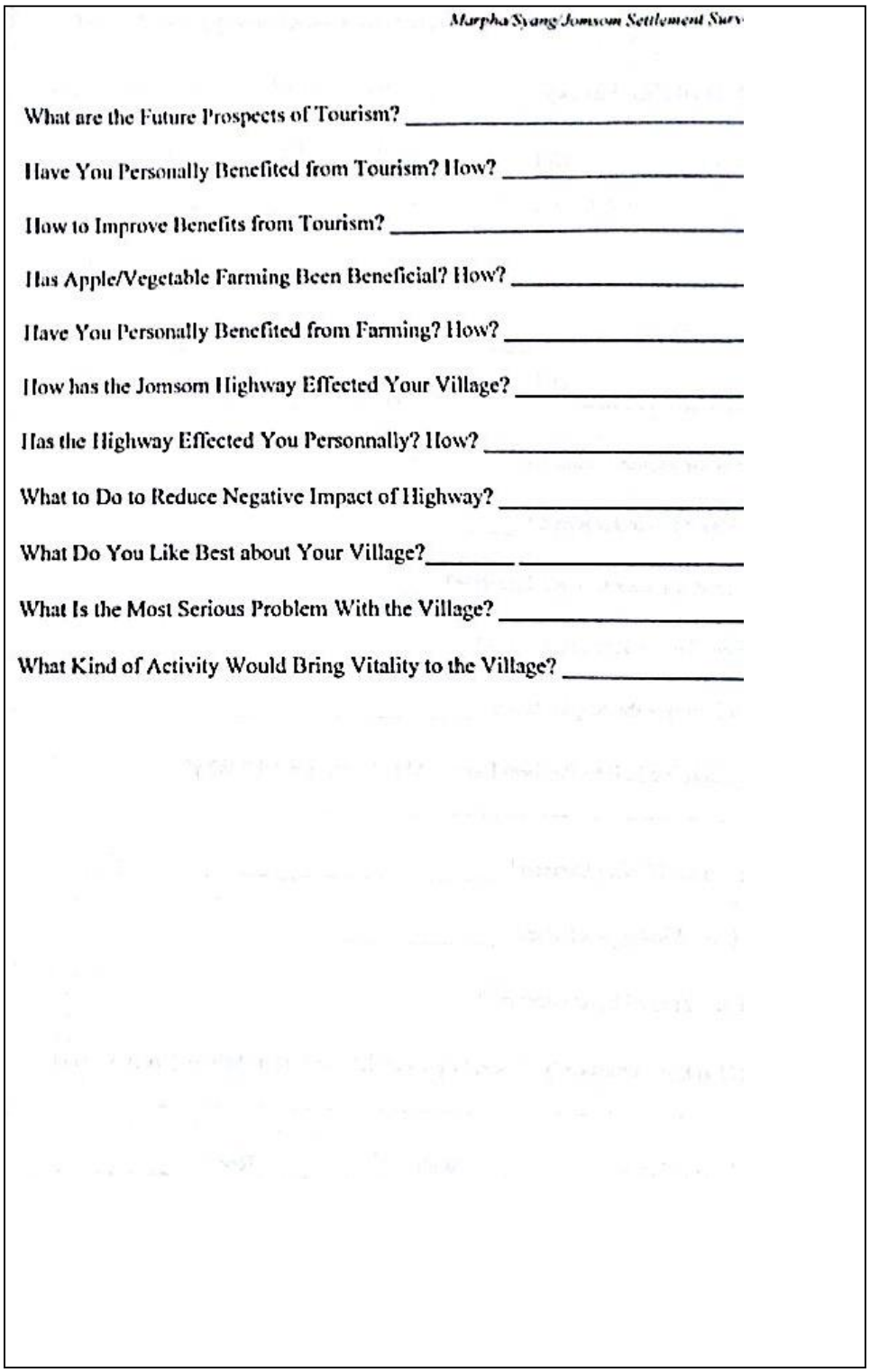
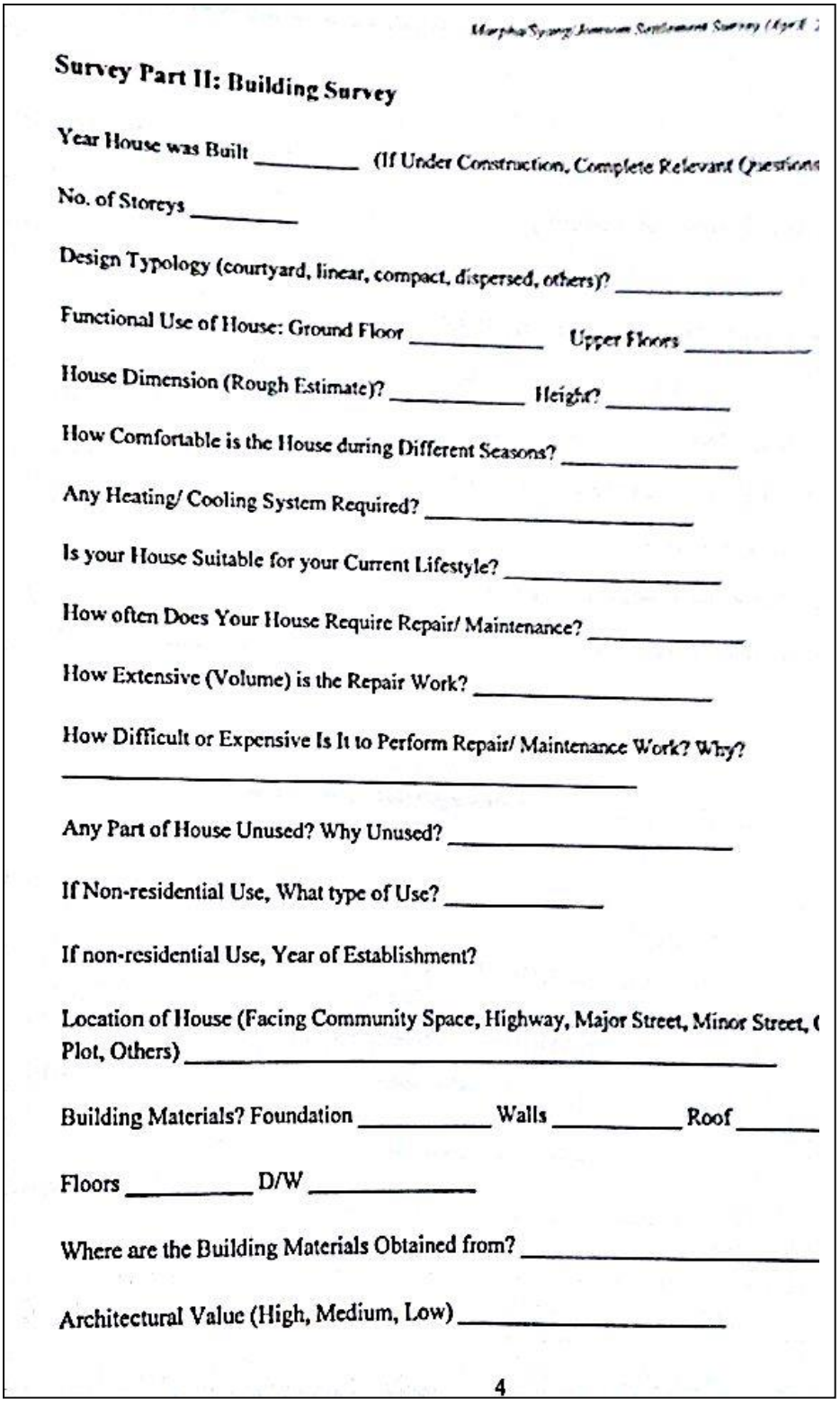


Figure 78, cont.



Survey Part II: Building Survey

Year House was Built _____ (If Under Construction, Complete Relevant Questions

No. of Storeys _____

Design Typology (courtyard, linear, compact, dispersed, others)? _____

Functional Use of House: Ground Floor _____ Upper Floors _____

House Dimension (Rough Estimate)? _____ Height? _____

How Comfortable is the House during Different Seasons? _____

Any Heating/ Cooling System Required? _____

Is your House Suitable for your Current Lifestyle? _____

How often Does Your House Require Repair/ Maintenance? _____

How Extensive (Volume) is the Repair Work? _____

How Difficult or Expensive Is It to Perform Repair/ Maintenance Work? Why?

_____

Any Part of House Unused? Why Unused? _____

If Non-residential Use, What type of Use? _____

If non-residential Use, Year of Establishment?

Location of House (Facing Community Space, Highway, Major Street, Minor Street, (
Plot, Others) _____

Building Materials? Foundation _____ Walls _____ Roof _____

Floors _____ D/W _____

Where are the Building Materials Obtained from? _____

Architectural Value (High, Medium, Low) _____

4

Figure 78, cont.

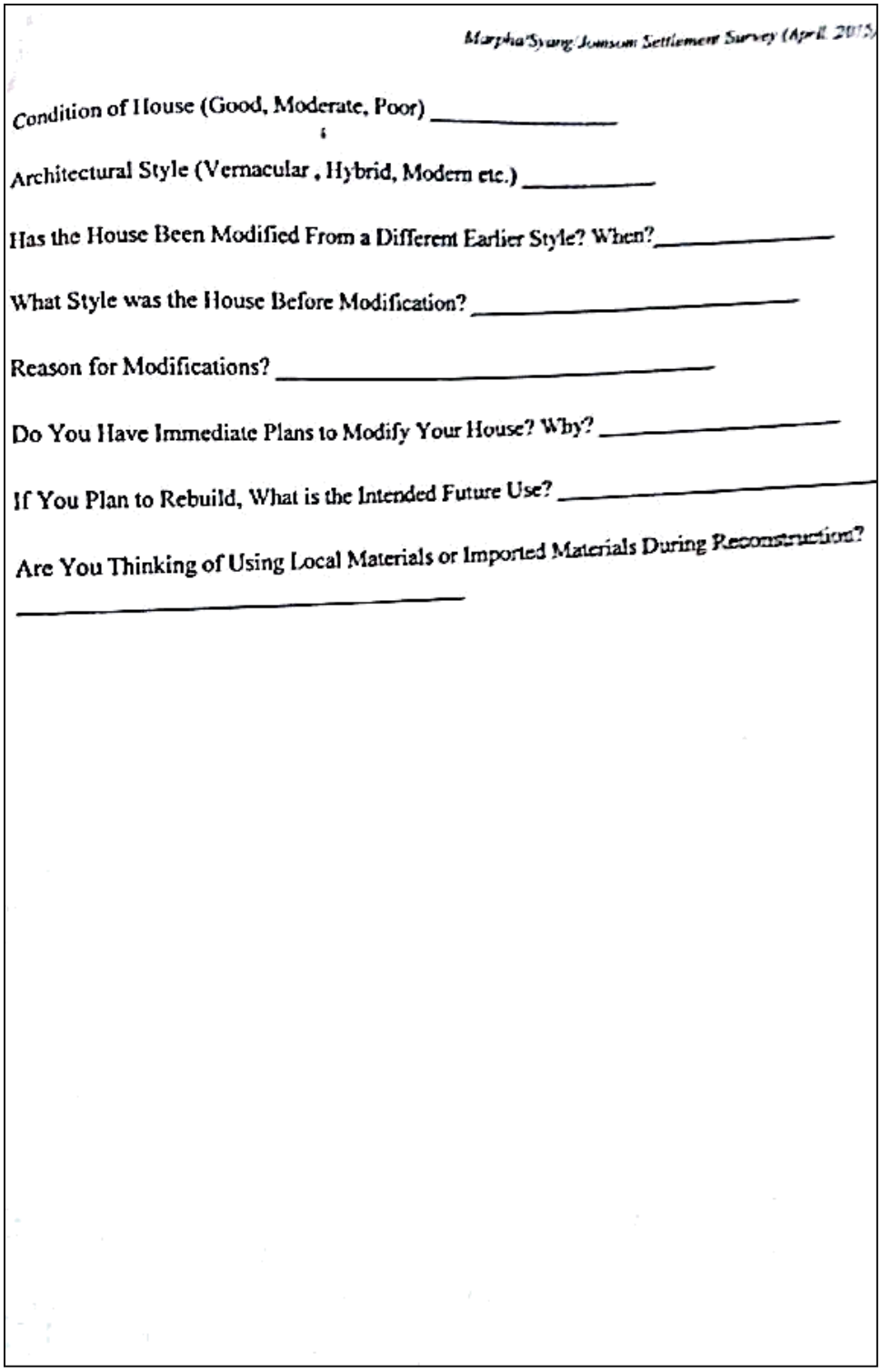
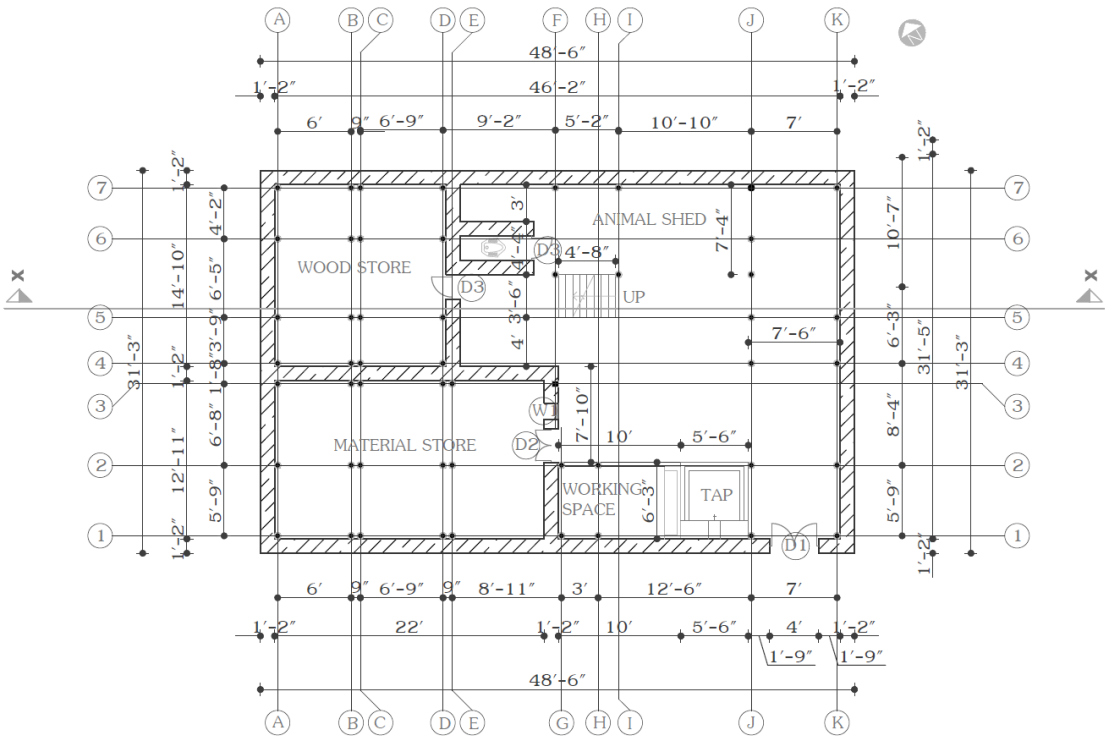


Figure 78, cont.



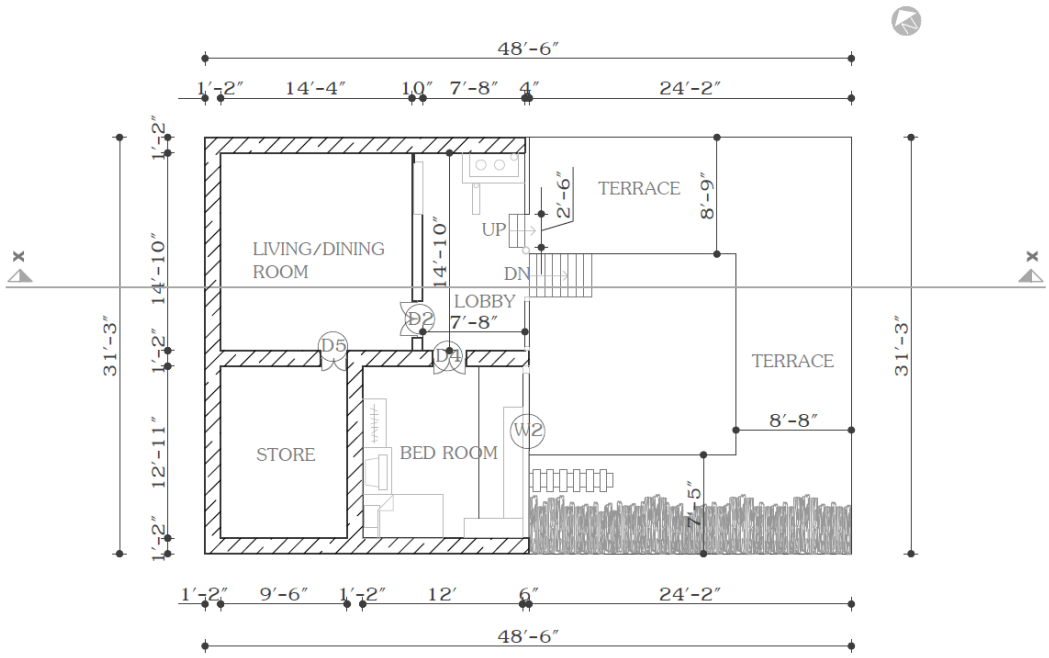


Figure 79: Showing the floor plans of the case study building

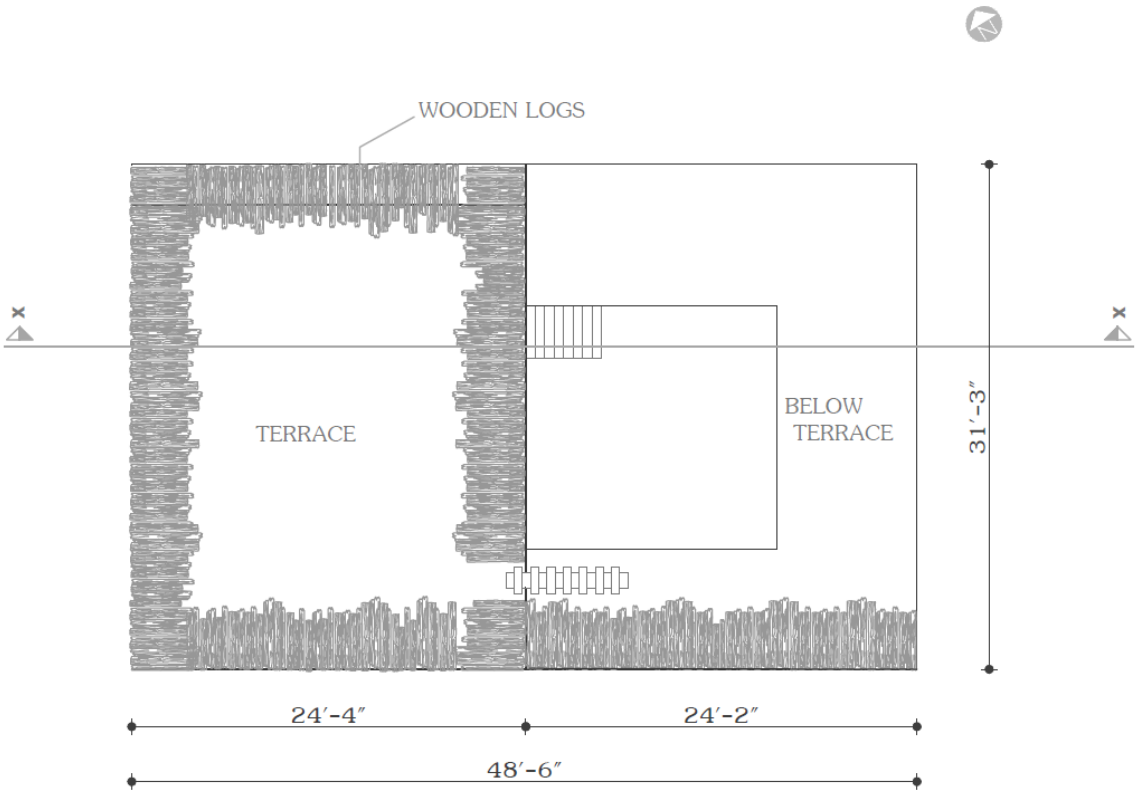


Figure 79, Cont.

Glossary

LDC: Least Developed Countries

RCC: Reinforced Cement Concrete

RAJA: King

DALIT : Lower Caste people involved in labor works

THAKALI : Caste from Himalayas kept by people living near “THAK” River

GUMBA : Buddhist Monastery for praying and meditation

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